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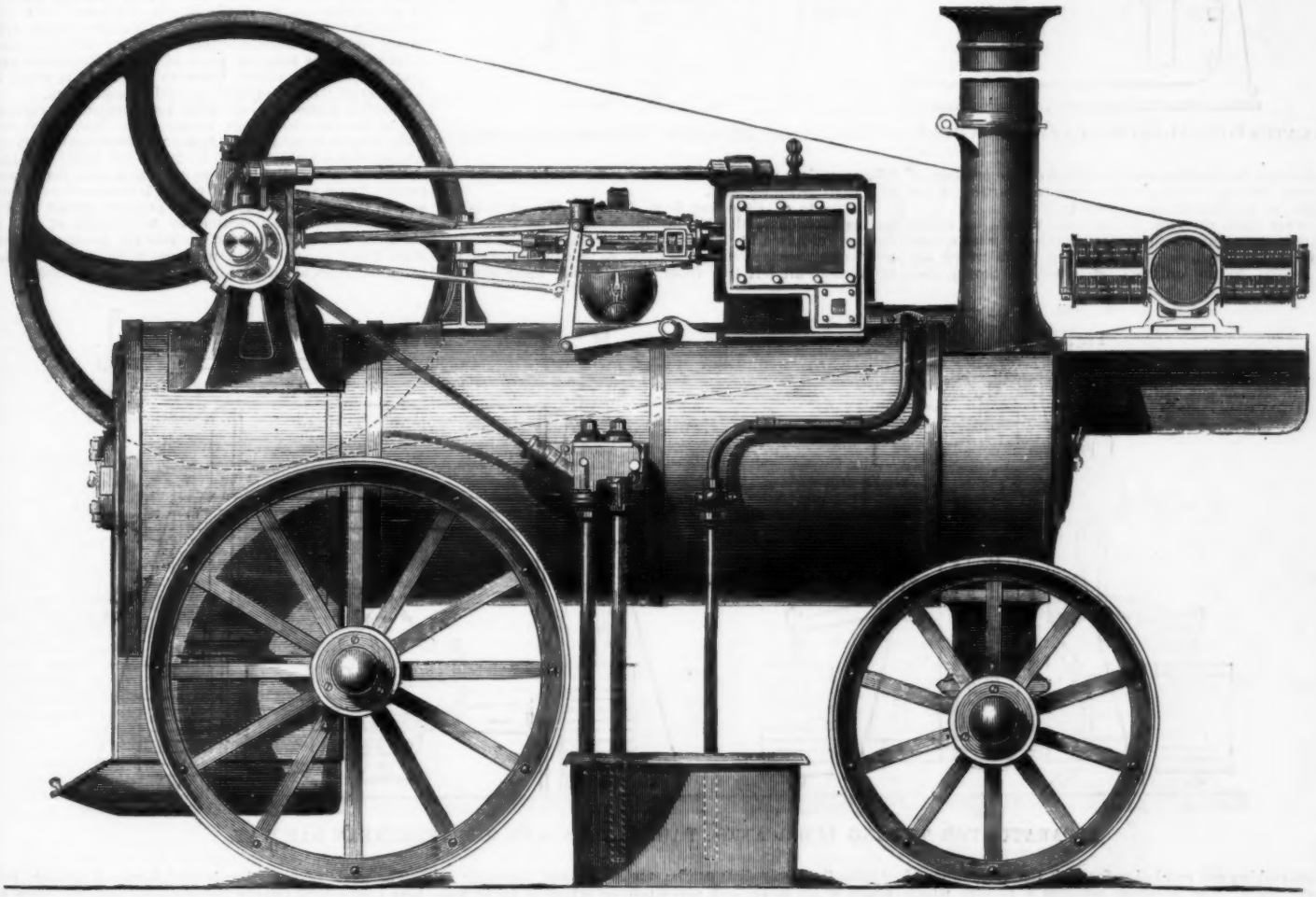
PORTABLE ELECTRIC LIGHT ENGINE.

In the various trials which have lately taken place with electric lighting, gas, steam, and even water have been used as motive power for driving the dynamo-electric machines; but when the machines have been attached to large fixed engines usually employed in factories, it has been found that the movement was not sufficiently regular, or that it was often necessary to keep a large engine at work at night simply to drive the electric light, an arrangement which necessitated a wasteful expenditure of coal and attendance to produce the light. It has been generally admitted that when the electric light is employed, whether for permanent or temporary purposes, it is advisable to have an engine adapted specially for the purpose of driving the machines, not only on account of the economy in fuel and labor, but also from the greater regularity which can be insured in the movement of the dynamo-electric apparatus.



PORTABLE ELECTRIC LIGHT ENGINE.

Messrs. Ransomes, Sims & Head have designed and manufactured a very neat combination of a portable engine and dynamo-electric machine on Siemens', Gramme's, or other well known system, the whole being mounted on four wheels, and easily transported from place to place. The engine is fitted with a patent automatic expansion gear, which is very sensitive and capable of regulating the number of revolutions of fly-wheel per minute with great accuracy —a matter of much importance to insure the proper action of all electrical machines.

This gear consists of two small eccentrics fixed on the crank shaft, and furnished with straps and rods fitted in the usual manner. The ends of the rods are connected together by a solid link, which slides in a block carried by the rod of the cut-off valve. The weigh shaft and supporting rod form the connection between the link and governor, which is on the Porter principle. The action of the whole is as follows: The eccentric, which is attached to the lower end of the link, is fixed at such an angle in relation to the crank as to effect an early cut-off, while the eccentric attached to the top of the link is set so as to allow a late suppression of the steam. When the load on the engine is diminished or increased, the governor instantly revolves above or below its normal speed, and by the rising or falling of its arms and balls, it shifts the link and brings the expansion valve more or less under the influence of the early or late cut-off eccentric, thus regulating the supply of steam to the altered load until the engine again makes its proper number of revolutions per minute.

The electric machines are fixed on a platform in front of the smoke-box, and a second fly-wheel can be attached when it is necessary to drive two machines for a double light. These engines are made of from 4 to 12 horse power, and, if necessary, the wheels can be taken off and the boiler fixed to the ground. Several of these engines have been made for driving electric lights in various parts of the world, and we think we may commend the design of their engine as a practical one, and likely to supply a want which has long been felt by many users of the electric light.—*The Engineer.*

FRENCH RAILWAY APPLIANCES.

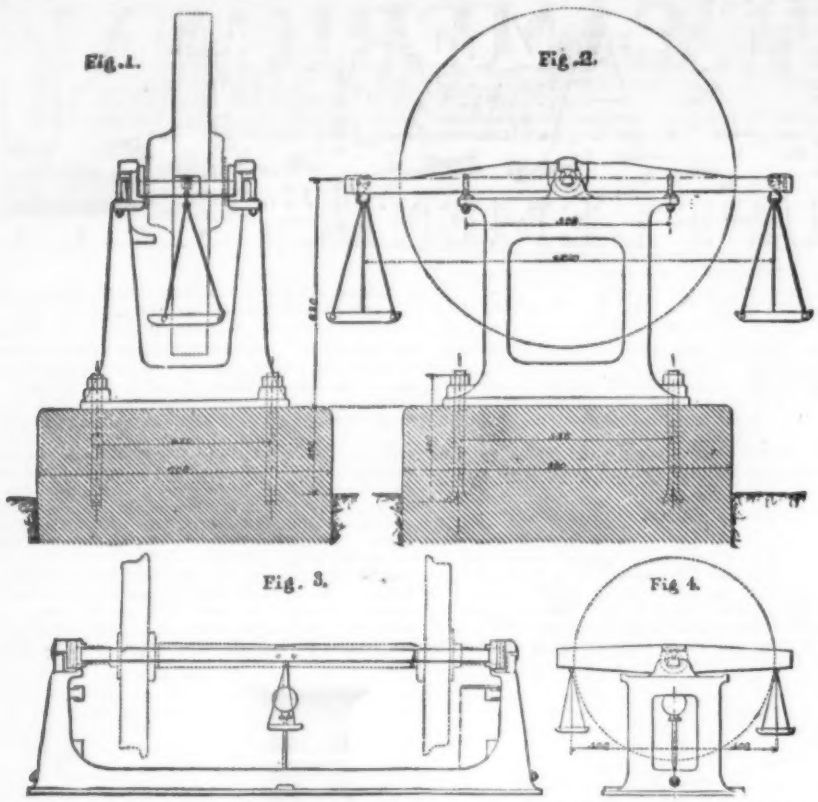
The Paris, Lyons, and Mediterranean Railway Company are very particular about the correct balancing of the wheels of their carriages, as they fully recognize the important part which such balancing plays in securing steady running of the vehicles, particularly at high speeds. The arrangements they employ for insuring the balancing just referred to were represented at Paris, and we give engravings of these in the illustrations, Figs. 1 to 4, on next page; views Figs. 1 and 2 showing the apparatus for ascertaining the balance of single wheel centers, and Figs. 3 and 4 that for dealing with a pair of wheels on their axle.

The two arrangements we illustrate are identical in principle and differ only in details. In that shown by Figs. 1 and 2 the wheel center, after being turned and bored, has a slightly tapered mandrel fitted to the hole in its boss, and is then mounted in a frame with the ends of the mandrel resting in carefully formed V's. If it were possible for the wheel to turn without friction between a pair of centers like those of a lathe, of course no further provision would be necessary, and the extent to which the wheel was out of balance might be ascertained by applying weights directly to its rim. But the friction of such centers would prevent small defects of balance from being discovered, and to obviate this and to obtain greater delicacy the wheel is in the apparatus we are describing carried in a frame, which is in its turn mounted on knife edges, as shown, the line of bearing of these knife edges corresponding accurately with the axis of the mandrel upon which the wheel is fixed. The wheel can thus be turned round in the V's to test its balance in different positions, and in each case it has great freedom of motion (by the rocking of the frame on the knife-edges) without turning between centers at all. Scales hung to the frame as shown enable the amount by which the wheel is out of balance to be ascertained.

The process of testing the balance of a wheel may be divided into two operations, namely, first, the determination of the direction of the eccentricity; and secondly, the amount of that eccentricity. The determination of the direction of the eccentricity is performed thus: The wheel, being mounted on the frame in any position, is balanced by placing shot in one of the scales until the frame is brought into the horizontal line, and a mark corresponding to a vertical line drawn through the knife-edges is then marked on the wheel rim. The weight placed in the scale being allowed to remain undisturbed, the wheel is then turned round within the frame until it is found that the weight first placed in the scale again suffices to balance it, and when this position has been ascertained, another mark is made on the wheel rim corresponding to a vertical line drawn through the knife-edges. A bisection of the space between the two marks on the rim thus made gives a point removed 90 deg. from that which would indicate the direction the wheel is out of balance. Next, to ascertain the amount the wheel is out of balance, it is turned round until the bisecting mark just referred to is brought behind the plumb line which marks the vertical through the knife-edges, and it is balanced by a weight placed in one of the scales, a mark being made on the wheel rim on the opposite side to the loaded scale to indicate the direction in which the wheel is out of balance. The operation is then repeated with the wheel turned round through 180 deg., and rebalanced by a weight placed in the other scale, the mean of the two weights being taken as indicating the amount the wheel is out of balance. In dealing with a pair of wheels mounted on their axle the mode of operation is precisely similar.

APPARATUS FOR TESTING LUBRICANTS.

The engravings on next page show an apparatus exhibited by the Paris, Lyons, and Mediterranean Railway Company at Paris, and employed by them for testing the values of different lubricants. The apparatus, which was constructed at the Paris workshops of the company, consists of a pair of strong frames, carrying bearings in which runs a shaft carrying a pair of wheels, of which the rims are placed at the same distance apart as the lines of rail, namely, 4 ft. 8½ in. Resting on these wheels is placed a pair of ordinary carriage wheels, mounted on their axle as shown, this axle being fitted with a pair of axle-boxes as it would be on a carriage, the upper part of the side frames of the machine serving the purpose of horn-plates. Resting on the axle-boxes is a pair of springs, to the ends of which loads are applied by means of the arrangement of links and weighted levers, shown clearly in Fig. 1, the weights on the levers being varied as required. A screw is also coupled to the center of each spring, the nuts of these screws forming wormwheels and being connected by a cross-shaft carrying two worms as shown. By turning this cross-shaft the two

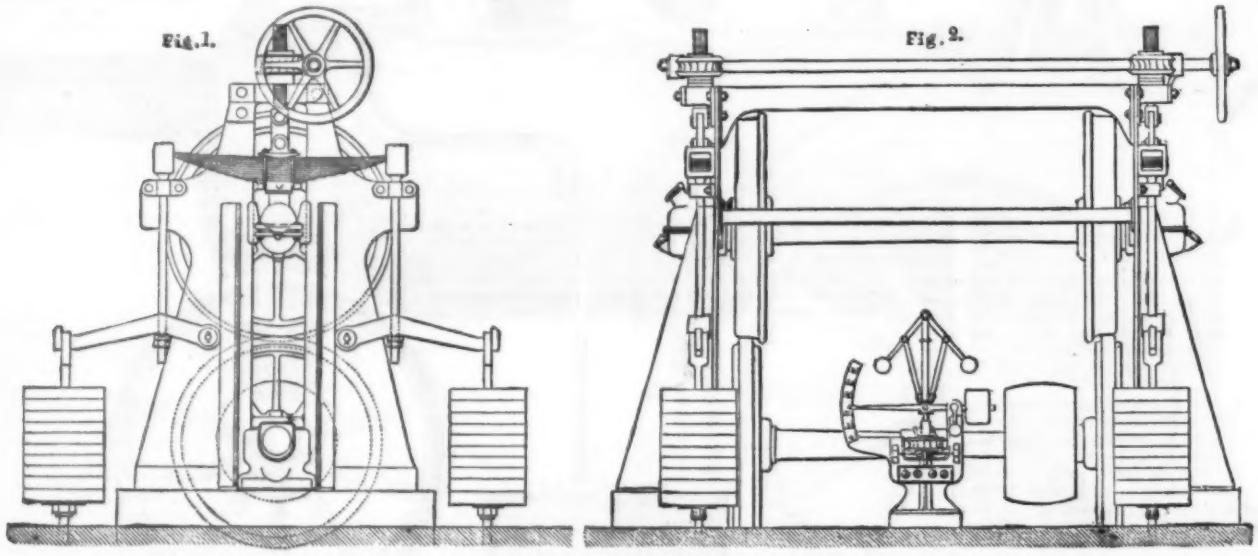


APPARATUS FOR BALANCING CARRIAGE WHEELS; PARIS, LYONS, AND MEDITERRANEAN RAILWAY.

axle-boxes can be simultaneously relieved of the pressure of the springs, the object being to facilitate the starting of the apparatus, as we shall explain presently.

The lower shaft carrying the friction wheels, on which the upper or running wheels rest, is furnished with a wide belt pulley, and it also has at its center a worm which imparts motion to an ordinary governor, as shown, this governor making one revolution for each ten revolutions of the lower shaft. The governor actuates a pointer which indicates approximately on a scale the surface speed of the rims of the wheels in kilometers per hour. The friction wheels on the lower shaft, we should mention, are mounted eccentrically to the extent of 2½ millimeters (0.1 in.) so as to impart a slight vertical oscillation to the upper wheels when running, and thus imitate to some extent the jolting of a carriage on the rails.

The mode of operating is as follows: The axle-boxes having been charged with the lubricant to be tested, the springs are raised by means of the arrangement of screws and worm-wheels already described, so that the axles of the upper shaft are left free from load. Under these circumstances the lower shaft can be started without throwing an undue strain on the belt, and when the whole is fairly running the springs are gradually eased down so as to impose the desired pressure on the axle-boxes. In determining the relative value of different lubricants, that is considered to be the best which permits of the highest load upon the bearings and the highest speed without heating. This mode of testing does not permit of an accurate measurement of the frictional resistances with the different lubricants, but it affords a good mode of estimating their practical value, the avoidance of hot bearings being rightly considered a matter of great importance in railway working.



APPARATUS FOR TESTING LUBRICANTS; PARIS, LYONS, AND MEDITERRANEAN RAILWAY.

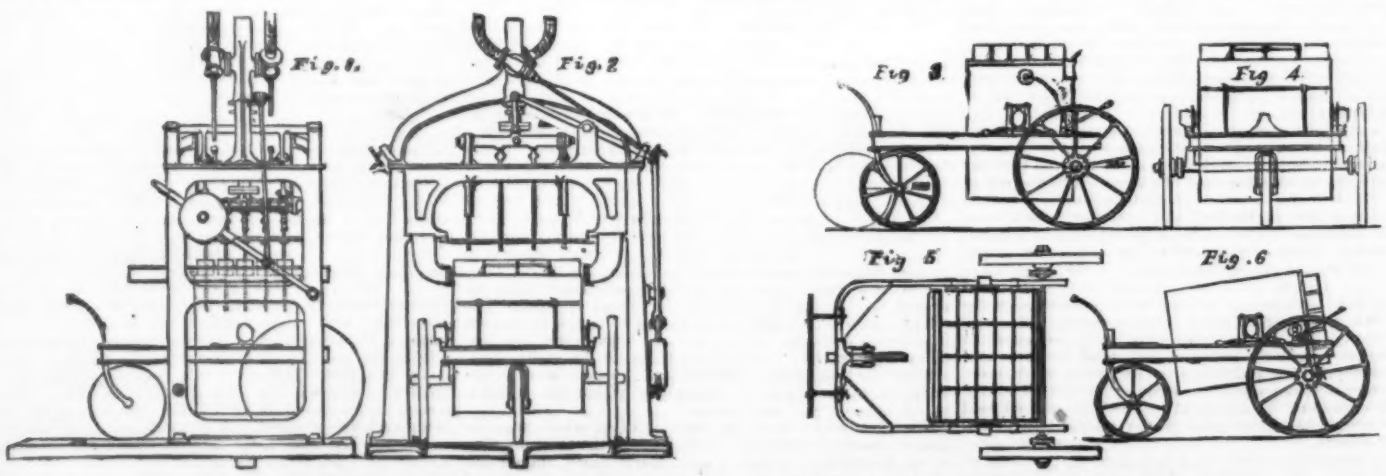
DEVICES FOR FILLING AND HEATING FOOT-WARMERS.

The last exhibits of the Paris, Lyons, and Mediterranean Railway Company which we have to notice in connection with the subject of the present article, are the examples of the arrangements employed by the company for heating foot-warmers for railway carriages. One of these arrangements—intended for use at important stations—is shown by Figs. 1 to 6 below, while Figs. 7 and 8, next page, represent an arrangement adapted for stations of the second class. In both these arrangements the water in the foot-warmers is heated to about 185 deg. Fahr. by the injection of a jet of steam, a mode of heating which has been adopted on several of the French lines, and which is much more expeditious than the plan of emptying the foot-warmers and refilling them with hot water, as is generally the practice here.

At the large stations of the Paris, Lyons, and Mediterranean Railway, each set of plant for heating the foot-warmers consists of one or two heaters properly so-called, and a number of tricycles, or handy three-wheeled trucks, on which the foot-warmers can be conveyed from the heaters to the carriages, and *vice versa*. In the arrangement shown by Figs. 1 and 2 each heater, or *herse* as it is called, consists of a pair of neat cast-iron standards braced together at the top, and fitted with a sliding frame, which can be raised or lowered by means of the arrangement of hand levers provided for that purpose. The sliding frame carries twenty hanging tubes, as shown, arranged in five rows of four each, these tubes being all connected by horizontal tubes, which place them in communication with a main central tube, which rises from the center of the sliding, and works in a stuffing box carried by the upper crossbar of the fixed frame. By means of this sliding joint the main pipe of the sliding frame is placed in communication with a casting in which two cocks are fixed, one serving for the supply of water and the other of steam. By this arrangement the twenty hanging pipes of the sliding frame can be made to discharge either steam or water into as many foot-warmers or "chaufferettes" placed beneath them.

The foot-warmers to be filled or reheated are carried by one of the tricycles shown separately in Figs. 3 to 6, below. Each tricycle consists of a frame mounted on two carrying wheels with a guide wheel in front, the frame carrying a sheet-iron casing divided into compartments for receiving twenty foot-warmers. This casing is mounted on trunnions so that it can be brought into the position shown by Fig. 6 for the convenient insertion or withdrawal of the foot-warmers, and can be turned up into the position shown in Figs. 1 to 5, to enable the warmers to be filled or heated, a catch being provided for keeping it in either position.

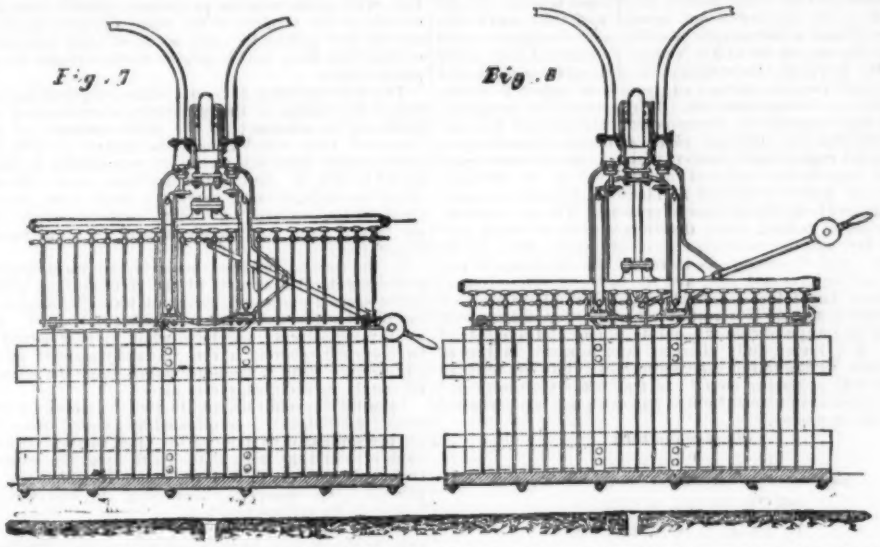
The mode of operating is as follows: A tricycle having been loaded with twenty foot-warmers, and the screw plugs of these warmers having been removed, is run into position under the heating apparatus, as shown in Figs. 1 and 2, and the sliding frame being depressed each pendent pipe enters into the corresponding foot warmer. Under these circumstances the warmers can either be charged with water, if



ARRANGEMENTS FOR HEATING FOOTWARMERS; PARIS, LYONS, AND MEDITERRANEAN RAILWAY.

empty, or the water in them can be reheated by the injection of steam. The process of reheating the water to a temperature of about 185 deg. Fahr. takes from three to four minutes, and one heating apparatus, such as shown in Figs. 1 and 2, working in connection with a steam boiler having about 270 square feet of heating surface, will reheat 240 foot-warmers per hour. Of course, when the foot-warmers are sufficiently reheated the sliding frame with the pendent pipes is raised, the tricycle with its load run out of the way to make room for another, and the screw plugs of the foot-warmers replaced, when they are ready for delivery into the carriages. It will be noticed that this mode of operating involves much less handling of the foot-warmers than that usually adopted here.

The arrangement of heating apparatus adapted for secondary stations, and shown by Figs. 7 and 8 on the present page, is similar in principle to that already described,



ARRANGEMENTS FOR HEATING FOOTWARMERS; PARIS, LYONS, AND MEDITERRANEAN RAILWAY.

but instead of being designed for reheating foot-warmers carried in groups on tricycles, it is arranged to deal with such warmers arranged in a single row in a rack which fixes their positions with respect to the pendent pipes of the sliding frame. Fig. 7 shows the apparatus with the sliding frame in its highest position, while Fig. 8 shows it in its lowest position. Each pendent pipe, it will be noticed, is furnished with a cock (as is also the case with the arrangement previously described), so that any number of pipes can be thrown out of use when desired. An apparatus of the type shown by Figs. 7 and 8, worked in connection with a steam boiler having about 160 square feet of heating surface, will reheat about 150 foot-warmers per hour.—*Engineering.*

USE OF COMPRESSED AIR MOTORS FOR STREET CARS.*

NEW YORK, February 20, 1879.

To HENRY HARLEY, Esq., General Agent of the Pneumatic Tramway Engine Company:

SIR: Candor compels me to acknowledge that I approached the consideration of the applicability of compressed air as a motor for street engines with no bias in its favor. Years ago when devising plans for tunneling the Hoosac Mountain, I had, after careful consideration, rejected compressed air in favor of steam in connection with a vacuum pipe as far more simple, economical, and efficient. At the Mt. Cenis tunnel the power actually utilized was not ten per cent. of the power expended in compressing air, even to six atmospheres, and at higher pressures the proportion of loss would have been still greater.

So also in any other mode of compressing air in which the direct pressure of steam is employed, as in reciprocating pumps, a cylinder of steam unexpanded and at maximum pressure, must be expended to secure under high tensions a small fraction of a cylinder of air at the same tension.

If a number of small compressors be connected with one shaft by cranks, at such angles as to divide the circumference equally, the loss of power or the percentage of useful effect would be increased.

Suppose, for the sake of illustration, that there were ten compressors connected with one shaft, and that it was proposed to compress the air to ten atmospheres. There would be ten discharges into the receiver at each revolution, each discharge being one-tenth of a cylinder, and the sum of the whole equal to one full cylinder at the proposed maximum tension.

The power exerted in effecting the compression in each cylinder would be in proportion to the mean pressure throughout the stroke, if the air cut off at one-tenth were allowed to expand, which is 3·302, and if the air was not used expansively the theoretical loss without allowance for friction would be as 3·3 to 1, and with friction fully as 5 to 1.

But the air can be and is used expansively, and the simple device of a fly wheel, by which momentum can be stored up and maintain uniformity during a revolution, secures equally favorable results with a small as with a large number of compressors connected with a shaft, and I see no reason whatever to question the results claimed for the compressors manufactured at the Delamater Works, and now used on the Second Avenue Railroad, of 50 horse power of compressed air, capable of being fully utilized for every 100 horse power expended in the engine which works the compressors.

But it will be said there is still a loss of one half as compared with steam applied directly. I answer, not so; and in this fact is found the key to the solution of the problem, and to me it was a most unexpected and satisfactory result.

The minimum of weight is essential in a locomotive engine. Heavy appliances for securing economy of fuel cannot by any possibility be applied to them. Compound and condensing engines are entirely inadmissible on wheels, but all the known economies in engines, regardless of weight,

* Report to the Pneumatic Tramway Engine Company of New York, by General H. Haupt, C.E.

can be introduced in stationary plant, and Corliss, Delamater, and others now secure as an ordinary result a duty of one horse power from 2½ pounds of coal.

At the Holly Works at Lockport, which claim an exceptionally high average duty, the daily evaporation is nine pounds of water to one pound of coal under 25 pounds pressure, or seven pounds of coal to one cubic foot of water evaporated; and in small boilers, such as are used for heating purposes, the average evaporation under ten pounds pressure is only four pounds of water per one pound of coal, or 15·7 pounds of coal per cubic foot of water evaporated.

One cubic foot of water evaporated per hour is usually taken as a horse power, but at one atmosphere effective pressure it produces rather less than 33,000 foot-pounds, so that the consumption of these small boilers would be fully 16 pounds per horse power.

With no very reliable data to determine the consumption of coal and evaporation of water in ordinary street motors, it will, no doubt, be greatly in their favor to credit them with developing a horse power with ten pounds of coal; and the conclusion therefore is, that although one-half the power of the stationary engine is lost in compressing air, yet the economy of fuel can be made so great that a given amount of power in compressed air is secured at one-half the cost of the direct application of steam to street motors.

But this is not all. By the simple device of heating the air by passing it through a tank of water it is claimed as the result of constant practice in Paris, confirmed by recent experiments on the Second Avenue Railroad, that the capacity for work is doubled, or the gain 100 per cent., making the economy of power as compared with the direct application of steam to street motors, measured, as it should be, by coal consumed, four to one in favor of compressed air. I propose to examine whether this claim can be considered theoretically well founded.

Air is compressed into the car reservoirs under a pressure of 350 pounds per square inch, or 24 atmospheres, nearly.

It is not applied directly to the motor cylinders at this pressure, experience having shown that the best practical results are secured at 16 atmospheres, about 240 pounds.

But the air is not applied cold; it is admitted to a tank of water placed on the front platform of the car, containing 5 cubic feet of water, drawn from a stationary boiler under 80 pounds pressure, and having a temperature of 328 degrees.

If the air is admitted to the tank at 60°, and leaves it at 328°, the increase of temperature will be (328—60)=268°.

To raise one pound of water from 32° to 212°, or 180°, requires as much heat as would raise 4·27 pounds of air through the same range. The specific heat of air as compared with water being as 0·2377 to 1, one pound of air increases in volume by heat from 12·387 cubic feet at 32° to 19·323 cubic feet at 328°=6·936 cubic feet increase.

The volume of air at 24 atmospheres being 1, the volume at 16 atmospheres would be 1·5. If the volume of air at 32° be 1, the volume at 60° will be 1·061, and at 328°=1·59. It appears, therefore, that in heating a given quantity of dry air to 328°, it will be increased in volume under constant pressure over 50 per cent., and under constant volume the pressure would be increased in the same proportion.

This expansion is due simply to dry air; when moisture is present to the point of saturation the pressures are greatly increased.

If air at 30° be taken as unity, dry air at 212° will occupy a volume of 1·375, and saturated air at the same temperature 2·672, or about double.

The expansion of 1,000 cubic feet of air, from 0° to 328°, can be determined from the formula:

$$v = V \times \frac{p+f}{P+F} \times \frac{458{\cdot}4+t}{458.4+T}$$

—in which V, P, T, and F are the volume, pressure, temperature, and elastic force of vapor or gas at the original temperature, and v, p, t, and f, at the increased temperature. Substituting, we find—

$$v = 1{,}000 \times \frac{32{\cdot}136+190}{32{\cdot}136+{\cdot}044} \times \frac{458{\cdot}4+328}{458{\cdot}4+0}$$

$$v = 1{,}000 \times 6{\cdot}9 \times 1{\cdot}716 = 11{,}840.$$

Conceding that only a small part of this theoretical expansion can be realized in practice, as the air when expanded in the motor cylinders is cooled very rapidly, and there are other losses, there is still a wide margin to justify the claim of double power from heating the air. I admit I was incredulous when I saw it first stated as the result of experiments in Paris, and when your very intelligent engineer, Mr. Hardie, assured me positively that the declaration was fully sustained by actual work on the Second Avenue Railroad, where double runs of 6¼ miles had been accomplished with the same expenditure of moist and heated air as single runs of 3¼ miles with dry air; but I am now prepared to credit the assertion, and the inevitable conclusion that results therefrom, that the power secured and utilized in air compressed with the best engines and compressors now in use costs, as compared with ordinary steam street motors, only one fourth as much per horse power measured by the coal actually consumed.

The air is not admitted to the motor cylinder at 350 pounds pressure, but at a much lower pressure, so that after passing the tanks and becoming heated and charged with vapor, it enters the cylinder at 250 pounds, requiring but a comparatively small volume of the dry air from the reservoirs to do the work.

This uniformity of pressure is secured by means of a reducing valve placed in the pipe, which acts automatically until the pressure is reduced below the pressure of admission. When the air has become so far exhausted as to fall below this pressure, the reducing valve remains fully open.

If the water should be cooled down 100 degrees the power of the heated air would be reduced, but would still retain great efficiency.

It can readily be understood, therefore, that a very important gain results from heating the air, and the economy of the arrangement is so great that it should never be omitted.

REDUCTION OF THE TEMPERATURE OF THE WATER IN RUNNING A GIVEN DISTANCE AND THE COST OF HEATING THE AIR.

Suppose one mile be taken as the distance run. The tank contains 5 cubic feet of water=62½×5=312 pounds, and 312 pounds contain a total above zero of 312×328=102,336 units.

The motor cylinders are 6¼ inches diameter and 13 inches stroke, containing each 431·38 cubic inches, and the two cylinders 862·76 cubic inches.

Allowing 3 per cent. clearance the cubic contents of each revolution of the wheels will be one cubic foot very nearly.

The diameter of the wheels being 28 inches, the number of revolutions in one mile will be 5280÷(28×3·1416÷12)=720, and the expenditure of mixed air and vapor will be 720 cubic feet in one mile.

Assuming the work actually done to be doubled by the heat and vapor, one half or 360 cubic feet per mile at atmospheric tension will be estimated as the consumption of dry air. Thirteen cubic feet of dry air at the temperature of 60° and atmospheric pressure weigh one pound, and the specific heat of air being 0·2377, it will require 13÷0·2377=54 cubic feet of dry air raised one degree to be equivalent to one pound of water, or to absorb one unit of heat for each degree of temperature. As 360 cubic feet of dry air are expended in one mile, 360÷54=6·6 heat units required for one degree, and to heat 360 cubic feet of air from 60° to an average temperature of 256°=196° will require 196×6·6=1,294 units.

But the air does not remain dry in passing through the tank. It has been demonstrated by actual work on the Second Avenue Railroad that in three trips of 9¾ miles, starting with 350 pounds and finishing with 85 pounds pressure, the water absorbed was 3 inches in a tank of 20 inches in diameter, which is very nearly 4 pounds of air to one pound of water expended. 4 pounds of air=4×13=52 cubic feet and 360÷52=7 pounds of water nearly consumed per mile, and at an average temperature of 256°, the number of heat units absorbed per mile in water would be 256×7=1,792, and adding the 1,294 units required to heat the air, the total units absorbed per mile will be 1,792+1,294=3,086. As the tank contained above 212° 36,192 units, 36,192÷3,086=11·7 miles as the run for which the water should suffice.

It is not claimed that these calculations are rigidly exact, for the amount of vapor condensed in expansion in the cylinders and cooled by radiation it would be difficult to compute, and is unnecessary. As the work is conceded to be doubled by the use of the hot water, it simplifies the problem to assume a half instead of a full cylinder of air to do the work, leaving heat and vapor to supply the balance.

COST OF HEATING THE AIR PER MILE.

To raise 5 cubic feet of water from 212° to 328° requires, as we have seen, 36,192 units, or 1,251 units per mile. Allowing 8,000 units of heat per pound of coal consumed, the coal required to heat the 5 cubic feet of water would be 36,192÷8,000=4·5 pounds, at a cost of one cent, and this is less than average duty.

It would seem from the result of this calculation that fully 100 per cent. has been added to the power of the engine and to the miles run, at a cost of one cent in coal for heating the water.

HOW MANY MILES WILL THE PNEUMATIC MOTOR RUN?

The air reservoir contains 160 cubic feet at 24 atmospheres. The equivalent at one atmosphere is 3,840 cubic feet. Allow one-third to be retained as reserve, there will be left to be utilized 2,560 cubic feet. But in consequence of vapor and expansion by heat, this quantity is practically equivalent to 5,120 cubic feet at the escaping tension. The number of cubic feet of air and vapor expended per mile run has already been ascertained to be 720 cubic feet; and 5,120÷720=7.1 miles nearly, still leaving a reserve of one-third.

But it has been found that the actual performance exceeds this theoretical limit, and that starting with 350 pounds pressure, 9¾ miles have been run with a reserve of 85 pounds. How can this be accounted for? Simply by the fact that the estimate of 7·1 miles was based on the supposition that a cylinder of mixed air and vapor at atmospheric tension was expended at each stroke. If nearly 50 per cent. more duty was actually secured, it proves that less than a cylinder of air and vapor did the work.

But, it may be asked, how is this possible? How can expansion be carried beyond atmospheric tension without creating a vacuum, and losing power by working against back pressure? This question I asked of Mr. Hardie, and the explanation brought to light another beautiful feature of his motor. There are valves called suction valves in the exhaust passages, and whenever the tension of air in the cylinder falls below that of the atmosphere, these valves open and permit the stroke to be completed without back pressure, so that it is not necessary to use more air than will overcome the resistances, and this may vary from a full cylinder to a very small fraction, or between limits as extreme as one to thirty.

INCREASED POWER FROM MOTOR CYLINDERS ACTING AS AIR-PUMPS.

The motor cylinders are so arranged that in descending steep grades they act as air pumps, and at the same time as brakes, by which means it is found, as stated by the company's engineer, Mr. Hardie, that in running down grade on the Second Avenue Railroad, pumping back against a pressure of 200 pounds in the receiver, the pressure was increased 7 pounds in a distance of 0.4 mile. As it requires 360 cubic feet to run one mile, 0·4 mile would require 144 cubic feet.

If the pressure were increased 7 pounds in a receiver containing 160 cubic feet at 200 pounds, the air pumped back would have been 5·3 cubic feet at 200 pounds in 0·4 of a mile, equal to 69 cubic feet at atmospheric tension, which is about half the amount of air that would have been expended in running an equal distance with the aid of the heat on a level, with a consumption of one cylinder of air at each stroke, but with actual results 50 per cent. greater.

To appreciate the importance of this result it must be observed that not only is all the air saved in running down hill and not a particle used, but half as much or more as would have been expended with the aid of heat and vapor upon a level is pumped back again, and at the same time the action of pumping back acts as a most efficient brake, the efficiency of which is spoken of by the intelligent mechanical engineer of the Delamater Works in terms of the highest commendation.

This is certainly a most extraordinary result, and so large a percentage of gain is only possible in consequence of the great expansion in the motor cylinders. The air and vapor escape at the tension of the atmosphere, without the noise which attends the escape of high pressure steam. When the air at atmospheric tension is pumped back again, it can readily be perceived that a certain percentage of the power expended will be restored, since only half a cylinder of air or less is required to do the work at each stroke.

Such a contrivance can only be characterized as admirable, and, it will be perceived, adds another considerable percentage to the gain in coal as compared with steam motors.

When a locomotive engine shall, while running, be able to manufacture coal and store it in the tender, it will then be able to rival this performance of the pneumatic motor.

It has been shown that at atmospheric tension the contents of the motor cylinders are just one cubic foot for each revolution of the car wheels, and that there are 720 revolutions per mile. There should be pumped back therefore 720 cubic feet, if the inclination were steep enough to employ full power, and which I find by computation to be 198 feet per mile; and when heated, saturated, and expanded, this air should run the car two miles or more instead of one. In other words, while running down hill one mile on a grade of 198 feet, the motor theoretically might store up enough to run it two miles on a level; and recent experiments have shown that 50 per cent. may be added to this estimate.

HEAT AND COLD BY COMPRESSION AND EXPANSION.

In some forms of pneumatic apparatus much inconvenience has been experienced from the heat liberated in compression, and again from the intense cold resulting from expansion, which deposited ice in the cylinders and ports when moisture was present, as it always is in air in its ordinary condition. It has been stated by writers on pneumatics that one pound of air at one atmosphere and at 60° compressed to two atmospheres is heated 116°, and the units of heat liberated per pound are $0.238 \times 116 = 27.6$ units.

Conversely, the expansion of air causes an absorption of heat or production of cold to a corresponding extent.

The compressors constructed at the Delamater Works in New York secure absolute exemption from the inconveniences both of heat and cold. The apparatus now in actual use on the Second Avenue Railroad consists of an engine with two steam cylinders 12 inches diameter and 36 inches stroke, operating two double acting compressors of same stroke, one of which has a diameter of 13 inches and the other a diameter of 6½ inches.

The number of strokes per minute in charging a car are 76 at the commencement and 70 at the end; the difference being caused by the difference in work to be performed.

The fly-wheel weighs about 4 tons, with a diameter of about 10 feet.

The air cylinders are jacketed, and a current of cold water circulates around them continually.

The air compressed in the first compressor to about five atmospheres passes into a tank of water in which the water is kept cold, and from thence into the second compressor, where it is reduced in volume one-fifth a second time, making one-twenty-fifth of its original volume.

The water tanks perform a most important office, not only in cooling the air, but, strange as it may seem, in drying it also.

The explanation of this apparent inconsistency is simple: Ordinary atmospheric air contains more or less water, which on reduction of temperature below the dew point is deposited to a certain extent on cold surfaces.

In compressing 25 cubic feet of air into one, and cooling it with water, it is estimated that twenty-four parts out of twenty-five of the water will be absorbed and removed.

When this dry air is again expanded by being utilized in the motor, it cannot deposit ice, because there is no contained water to form ice, and hence the fact, which it is said has excited great surprise amongst observers, that no frost whatever was formed except on the outside of the pipes from condensation of outside moisture.

Mr. Hardie stated that when the pressure ran low and the temperature of the tanks fell below about 100° frost began to be formed. This is precisely as should be expected. If air, in being compressed to one-half its volume, liberates 116 degrees of heat, it must absorb an equal amount in expanding, and if the water has cooled so low as not to furnish sufficient heat to compensate for it, the moisture taken from the water tank must form frost to some extent.

It was observed by Mr. G. H. Reynolds, of the Delamater Works, that the heat liberated in proportion to the power secured was much less at high than at low pressures. The fact had not previously been brought to my attention, but I think a satisfactory explanation can be given. Imagine a vessel containing one pound of air at ordinary tension, 13 cubic feet, the base 1 square foot and height 13 feet. If, by means of a piston, this air should be forced into one-half the space, or 6½ feet, the pressure would be increased to 30 pounds, and the work done would be 21·328 foot pounds. One pound of water raised 1° is equivalent to 772 foot pounds, and as the specific heat of air is 0·238, $772 \times 0.238 = 184$, the foot pounds expended in heating one pound of air 1°. Then $21.528 \div 184 = 116°$ = the heat liberated in compressing one pound of air into half its volume.

Now suppose the 6½ cubic feet of air should be again compressed one-half, or to 3¼, the final pressure would be 60 pounds, and the space 3¼ feet, and the work 21·528 foot pounds as before, representing 116° of heat. But with these 116° of heat the pressure has been increased from two atmospheres to four, and in like manner from four to eight, from eight to sixteen, and from sixteen to thirty-two, would each require but 116°, and at the end sixteen atmospheres of additional pressure have liberated only as much heat as one atmosphere at the commencement; assuming that the heat when liberated has been absorbed so as to secure isothermal contraction of volume.

This consideration, with others, induces Mr. Reynolds to favor the use of much higher pressures, running up to at least 500 pounds; in this way double the power could be secured with an increase of weight only in the receivers. There are at present practical objections to this increased pressure, as mechanical difficulties prevent the proper utilization of pressure over 250 pounds, and all the extra power expended in compression would be lost. The only benefit would be in securing additional reservoir capacity. If these mechanical difficulties can hereafter be overcome, the use of pressures of 500 pounds would be a great advantage, and there would be no trouble in making the receivers sufficiently strong to carry it.

In the admirable system of water works machinery designed by Mr. Holly, of Lockport, steam admitted to one cylinder and there expanded is exhausted into and re-expanded in three others, securing great economy. If, instead of being of the same size, one large and one small motor cylinder were employed, and the air from the small cylinder exhausted into the water tank at the proper tension, say 125 pounds, to be moistened and heated and then sent to the larger cylinder at 250 pounds, possibly some such plan would permit the use of air at 500 pounds, in which, I fully agree with Mr. Reynolds, there would be great advantage; and I would here venture another suggestion in regard to future possibilities of compressed air. Why cannot it be compressed to high tensions by cheap power, transmitted for considerable distances through pipes, and used expansively in compound engines with heater, without the annoyance and risk of large boilers and coal consumption on the premises where the power is utilized? There is no reason to apprehend danger from this increase of pressure. The air receivers, unlike steam boilers, never deteriorate; the air being perfectly dry, and the receivers coated internally, there can be no rust; and if pressure is increased, the thickness of material can be increased also, and the factor of safety remain the same. Any defect of material or work would be revealed by proper tests, and if a rupture should occur, there would be only an escape of cold air—no steam and no fragments of iron. A cylinder, fully charged, was ruptured in France purposely by the fall of a heavy weight. The air escaped simply with a hissing sound; no fragments were projected as in explosions of steam boilers, and cold, not heat, resulted from the expansion.

(To be continued.)

[Continued from SUPPLEMENT No. 174, page 2760.]

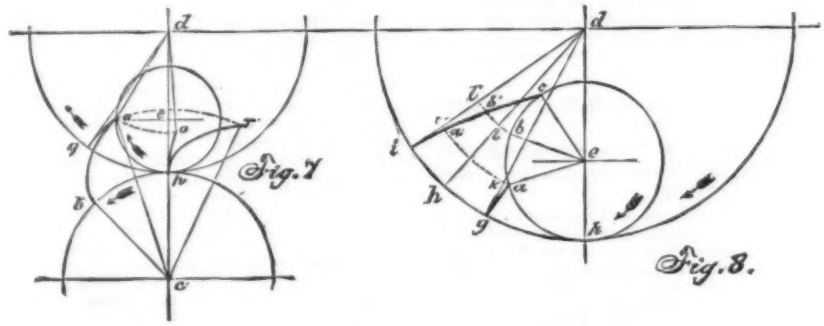
SKEW-BEVEL WHEELS.

By PROF. C. W. MACCORD.

No. 2.—The Tooth-Surfaces—How to Construct them.

WE come now to the consideration of the forms of the teeth, with which, practically, the hyperboloidal pitch surfaces must be furnished, in order to insure the transmission of rotation.

It was remarked in the preceding article that in the three cases of axes parallel, intersecting, and in different planes, tooth surfaces may be formed which are composed of rectilinear elements, two engaging teeth touching each other along a right line.



The method which we propose to explain, of constructing the teeth in the third case, will be made clearer, we think, if we begin by applying it to the first. Let us in Fig. 7 suppose c d to be the centers of the pitch circles of two spur-wheels, in contact at p. Let e be the center of a third circle tangent to both the others at the same point, p; then these three circles will roll together, turning about their fixed centers with equal circumferential velocities.

Suppose a pencil to be fixed at p in the circumference of the describing circle, e, and the rotation to progress as indicated by the arrows; then this pencil, in going to a, will trace on the plane of c the curve $b\,a$, and on the plane of d it will trace the curve $g\,a$, the arcs, $p\,a$, $p\,b$, and $p\,g$ being equal.

Let $p\,r$ be a curve equal and similar to $b\,a$, and $p\,o$ another like $g\,a$; then it will be clear that the former will push the latter before it, with a constant ratio between the angular velocities about d and c, until r and o come together at a.

If now we give sensible thickness to this system, the figure will represent two pitch cylinders in contact with a describing cylinder along an element perpendicular to the paper at p; and the curves, $b\,a$, $g\,a$, will represent transverse sections of the face-surface of a tooth on the wheel, e, and of a flank-surface of one on the wheel, d; and these surfaces will be tangent along a right line parallel to the axes.

We wish particularly to call attention to a special method of finding points in these curves, which, though less direct than the one usually employed, is perfectly accurate, and is more nearly like that presently to be used in constructing the teeth of skew-bevel wheels.

In Fig. 8, d, e, are the centers of the upper pitch circle and the describing circle of Fig. 7, p being the initial position of the describing point. As the rotation progresses, the generating radius, $e\,p$, will take successively the positions, $e\,a$, $e\,b$, $e\,c$; and the corresponding positions of the radius, $d\,p$, of the pitch circle will be $d\,g$, $d\,h$, $d\,i$, since the arcs, $p\,a$, $p\,b$, $p\,c$ are respectively equal to the arcs, $p\,g$, $p\,h$, $p\,i$. About the center, d, draw arcs through a and b; the first cuts $d\,g$ in k, the second cuts $d\,h$ in l.

Continue these arcs to cut $d\,i$ in k', l', and on them set off $k'\,a' = k\,a$, $l'\,b' = l\,b$. Then it is clear that a', b', will be points in the generated curve, $i\,c$; and in a similar manner we may construct the curve, $b\,a$, of Fig. 7.

In this case, then, the tooth-surfaces are simultaneously generated by a rectilinear element of a third surface, which rolls in contact with the pitch surfaces, and is of the same form or class with them, that is to say, cylindrical.

But the cylinder may be regarded as a cone whose vertex is infinitely remote; if we now place the vertex at a finite distance, the axes intersect, the pitch surfaces become cones also tangent along a right line, and the tooth-surfaces will be generated by a rectilinear element of a third cone rolling in contact with them.

Pursuing the analogy one step further, we see that just as the cylinder is but a special form of the cone, so in its turn the cone may be considered as the special form of the hyperboloid, in which the common perpendicular of the axis and generatrix has been reduced to zero, the gorge circle becoming a point, and forming the vertex of the cone.

And having two pitch hyperboloids, we can place a third one so that it shall be tangent to the others along their common element; in which case it will be clear that the direction and velocity of its rotation will be the same, by whichever of the pitch surfaces we consider it to be driven.

A rectilinear element of this describing hyperboloid, therefore, will, as the rotation progresses, generate two surfaces, exactly as the element of the third cylinder in Fig. 7 was seen to do; and by the very mode of their generation it is evident that these will be proper tooth-surfaces for the proposed wheels.

The determination of these surfaces requires that we shall follow the motion of this generating element, and locate its positions in reference to the pitch surfaces, at different phases of their rotation; and the manner in which this is most readily done will be found very similar to that illustrated in Fig. 8. But in the case there shown the elements of all the surfaces being parallel, a single view, showing the traces of the surfaces on a plane perpendicular to the elements and axes, was sufficient both for construction and illustration.

In the present instance, however, the trace upon a plane perpendicular to the axis of the pitch-surface, although it might serve a purpose in giving an idea of the nature of the tooth-surface, is not what is practically wanted. For just as in bevel gearing, the teeth when in gear would project beyond each other in a very unsightly manner, and would also be very weak at the outer points, were the wheels limited simply by such transverse planes.

In order to avoid this, and to give the wheel a presentable finish, the "blank" is terminated by a cone, whose elements are perpendicular to those of the pitch surface; and the problem is to find the trace of the tooth upon this normal cone. Or in other words, to find the points in which this cone is pierced by the generating element of the describing hyperboloid, in its various positions.

Let us suppose, then, that the surface with the vertical axis, in Fig. 9, is to be provided with teeth. The first thing is to decide on the size of the describing hyperboloid. Abstractly this is immaterial within certain limits, of which more will be said hereafter; for whatever its size, any element of it would generate the tooth surface as above explained. But there are practical reasons for making it such that the ratio of its angular velocity to that of the pitch surface shall be expressed by a simple fraction, such as ½, ⅔, or the like.

This figure illustrates the first steps of the process of determining the flank of the tooth; for this purpose the describing hyperboloid is made internally tangent to the pitch surface, and the velocity ratio is here assumed as 2 to 1. The construction of these in the two principal views will be clear from previous explanations; the normal cone, $k\,f\,g$, is formed by the revolution, about the vertical axis, of the line $f\,b$, seen in the top view as $c'\,b'$, which is normal to both hyperboloids at b, b'.

But for our purpose, a direct end view of the inclined hyperboloid is necessary, in which the axis appears as the point c'', the generatrix as $d''\,b''$, and $z\,w$ represents a plane through the axis and parallel to the generatrix.

Now let the describing surface turn through the angle, $b''\,c''\,o''$; the generatrix will then be seen in this third view as $o''\,r''$ (tangent at r'' to the gorge circle), and in the side view as $o\,r$. In the main top view, $o'\,r'$ is found thus: o' must be perpendicularly under o, and its distance, $x'\,o'$, in front of $d'\,b'$, is equal to $x\,o''$, in the third or supplementary view; so also r' is perpendicularly under r, its distance, $y'\,r'$, behind $d'\,b'$, being equal to $y\,r''$. In a similar manner we may find the projections of as many positions of the describing line as we please; then ascertaining the points in which the normal cone is pierced by it, we shall have the intersection of that cone by the small hyperboloid, whence by the method of Fig. 8 we may construct the trace of the flank of the tooth. It will conduce to practical accuracy, first to draw the elliptical projections of the gorge circle and the upper base of the describing hyperboloid in the top view, or at least portions of them, since the upper and lower ends of the parts of the elements here used lie in the circumferences of those circles, and the axes of the ellipses being known, the curves may be drawn with precision.

The process of finding the point in which a right line pierces a cone, is for the sake of clearness shown separately in Fig. 10. The plane of the cone's base is the circle, $k\,g$; and the given line, whose projections are $o\,r$, $o'\,r'$, pierces this plane in the point, p, p'. If we now pass a plane through this line and the vertex of the cone, this plane will cut from the cone a rectilinear element, which will evidently intersect $o\,r$ at the required point of penetration. In order to determine such a plane, we have only to draw through the vertex a line either parallel to the given line, or intersecting it at any point. Through f, then, draw the vertical projection parallel to $o\,r$, and through c' draw the horizontal projection parallel to $o'\,r'$. The line thus represented pierces the plane of the base at t, t'; therefore, $t'\,p'$ is the trace of the plane through the vertex, upon the cone's base, and this cuts the circumference in u, u'. Therefore, $u'\,c'$,

s f, are the projections of the element cut from the cone by the auxiliary plane, and *s*, *s'*, those of its intersection with the given line, that is to say, of the required point of penetration.

In this manner the point, *s*, *s'*, of Fig. 9, was found; and in applying the method of Fig. 8 for the purpose of determining a point in the trace of the tooth-surface, the advantage of using a describing surface of a definite size will be apparent. For, in the present case, the turning of the small hyperboloid through any angle corresponds to the rotation of the pitch-surface through an angle just half as great. Draw, then, in the top view, the radii, $o' b'$, $c' l$, including an angle equal to $\frac{1}{2}\ b'' c'' o''$; about c' describe an arc through *s*, cutting $c' b'$ in *a*, and $c' l$ in *i*, and set off $a c' = i s'$ (or, preferably, $s' c' = i a$); then c' will be the horizontal projection of a point in the trace of the flank of the tooth upon the normal cone, *g f k*, the vertical projection being *r*, on the horizontal line through *s*. And by repeating this process we map out the required curve.

The pitch-surface is here shown as extending to the gorge circle only. If $o r$, $o' r'$, be prolonged to pierce the plane of the gorge at *j*, *j'*, we may in like manner find a point in the trace of the flank upon that plane; recollecting that as the describing line pierces this plane, in its initial position, at *d*, *d'*, the angle equal to $\frac{1}{2}\ b'' c'' o''$, corresponding to $b' c' l$, is to be set off from the radius $c' d'$.

The point, *j*, *j'*, above mentioned, evidently lies in the intersection of the small hyperboloid by the gorge plane of the large one. For the sake of accuracy, this intersection, or a part of it, should be constructed with as much precision as possible; in view of which it is to be noted that the intersection of the hyperboloid of revolution by any plane cutting all its elements, is an ellipse; and the axes may be found as in Fig. 11. The cutting plane is L L, and it is evident that *a b* is the longest line that can be drawn on the section, being therefore the major axis. Bisect *a b* in *c*, through which point draw a perpendicular to the axis *m n* of the hyperboloid, giving *o r* as the radius of the transverse section, of which the half is shown by the semicircle, in which the ordinate *c d*, perpendicular to *o r*, is the semi-minor axis of the elliptical section required.

Although, in order to save space, we have shown the pitch-surface as limited by the gorge plane, it is clear, from what precedes, that the wheels may be extended to any distance on both sides of that plane, and that the teeth will be in contact from end to end. But practically, as in bevel gearing, comparatively thin frusta of the pitch-surfaces are used, and their location is optional, within certain limits hereafter to be noted. Thus, in Fig. 12, we may use the pair A, B, the pair C, D, or the pair E, F, at pleasure, or any two or all three pairs at once; and the steadiness of the motion will practically be greater when two pairs equidistant from the gorge planes are used.

The central pair, whose mid-planes are the gorge circles, may ordinarily be limited simply by transverse planes, as in the figure; the construction of the tooth-surfaces is then comparatively simple, their traces being derived from the elliptical sections of the describing hyperboloids by these transverse planes, determined as in Fig. 11.

It will subsequently be shown, however, that in practice the action is better if a pair like A, B, or E, F, be employed, and the larger ends at least should be limited by normal cones, for the reasons before given. The finish of the inner ends is of less importance; a transverse plane, since it cuts the teeth at an obtuse angle, will not weaken them at the points, as it would at the outer end; nor will the interpenetration of the teeth produce so disagreeable an effect.

Still it is more workmanlike to terminate the inner end also by a normal cone; it is just as easy for the mechanic, who actually makes the wheel, and not unreasonably laborious for the draughtsman, the trace of the tooth upon this second cone being found exactly as that upon the first one was. In the side view, Fig. 9, the generatrix and outline of this inner cone are shown in dotted lines, the base being indicated in the top view by the dotted circle; but in order to avoid confusing the figure, the operation of finding a point in the trace of the tooth is not shown.

The construction of the trace of the face-surface of the tooth is substantially the same in detail, for which reason we have not thought it necessary to illustrate it by a separate diagram. The describing hyperboloid is to be placed in external contact with the pitch-surface, and the normal cone sufficiently extended beyond the pitch-surface. The describing hyperboloid may or may not be the same as that used for generating the flank-surface; but the flank on one wheel, and the face on the other which works with it, must, as before pointed out, be generated by the same describing surface.

In laying out these teeth, even where the ultimate object is to make a drawing of a comparatively thin wheel terminated by cones, it will be advisable to find their traces on the gorge plane, or even on a transverse plane beyond; for the points in the projections of the describing line being thus placed farther apart, all the determinations will be more reliable in consequence.

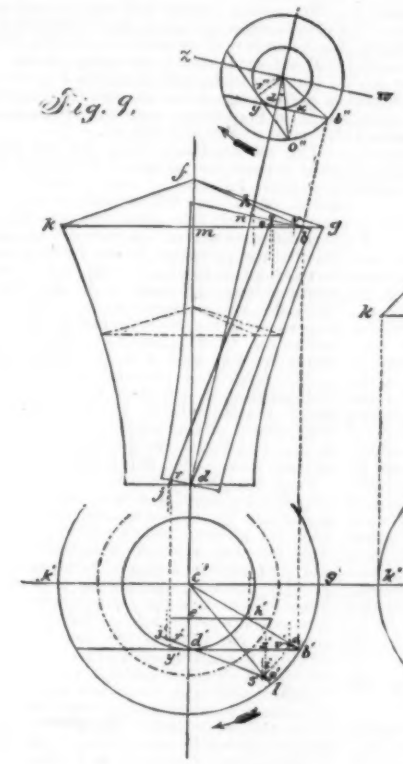
As in any other case of constructing a curve by points, the regularity, or as it is technically called, the fairness, of the curve, is a test of the accuracy of the work; it needs no argument to show that the intersections with the describing hyperboloid, and the tooth-traces derived from them, must be free from sinuosities and abrupt changes of curvature. Another check is found in this: that the teeth being composed of rectilinear elements, the corresponding points in the three traces mentioned, namely, one on each normal cone and one on the gorge plane, or another plane beyond, must, if the work be accurate, lie in one right line.

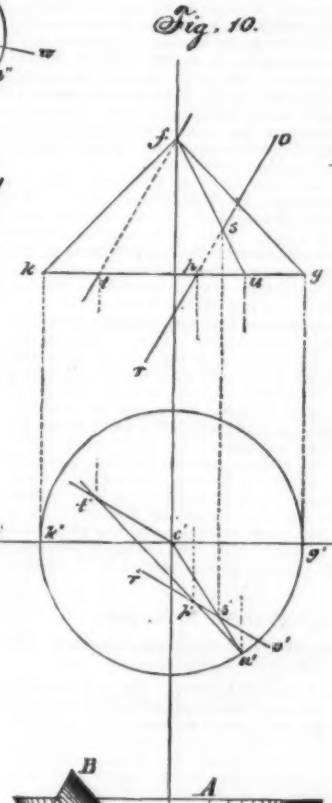
In Fig. 9 the rotation of the pitch and describing hyperboloids is assumed to be as indicated by the arrows. The flank-surface thus generated is, therefore, as in Figs. 7 and 8, that by which the wheel will be driven in that direction; and its traces are derived from those parts of the curves of intersection which lie in front of the initial position of the describing line, *d b*. In order to generate the flank by which the wheel shall be correctly driven in the opposite direction, this rotation must be reversed, and in finding its traces those parts of the curves of intersection which lie behind *d b*, as it is shown in the figure, must be employed.

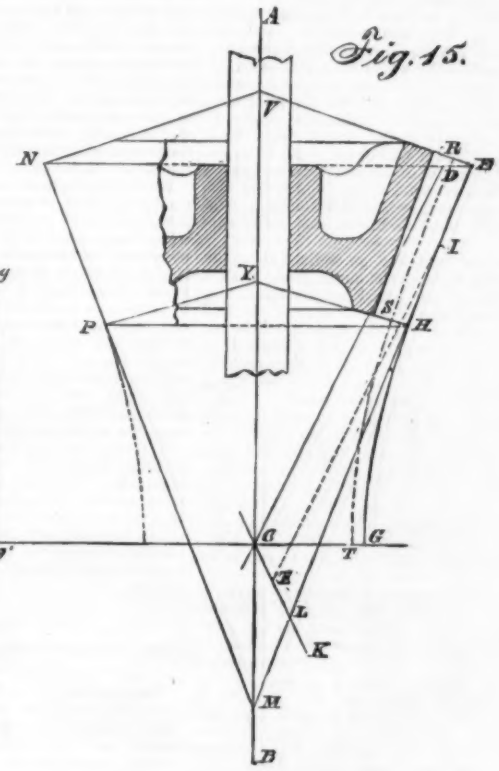
Now if the axes of the pitch and describing surfaces were in the same plane, the intersection of the latter with the cone normal to the former, would clearly be symmetrical with respect to that plane. But they are not, and the consequence is that this curve of intersection is not symmetrical with respect to the element, *f b*, of the normal cone. Therefore the traces of the two flank-surfaces, derived from the parts of this curve on opposite sides of the point *b*, will not be similar.

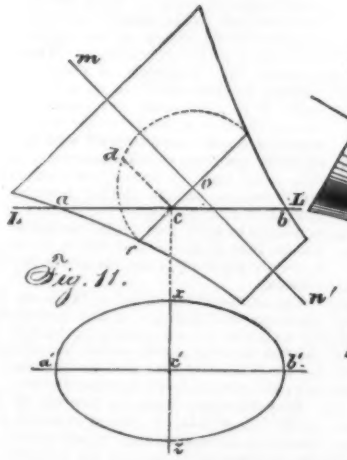
The same evidently holds true in regard to the face-surfaces, and the practical result is that the fronts and backs of the teeth of these wheels are not alike.

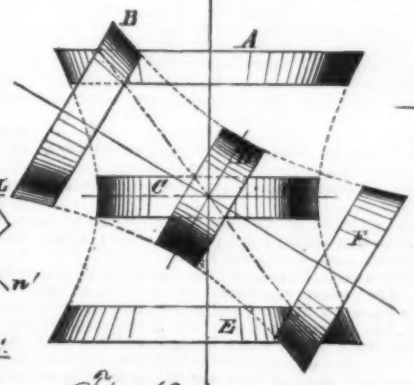
This may be seen from another point of view, thus: the inclinations of the describing line to the elements of the normal cone do not vary in the same manner or degree in the two directions of the rotation.

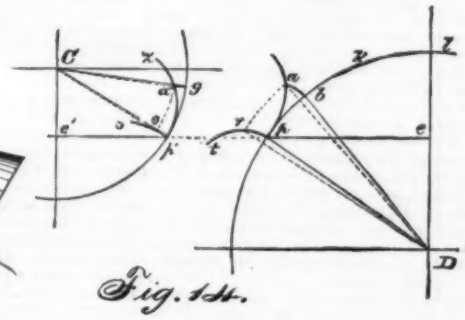












SKEW-BEVEL WHEELS.—BY PROF. C. W. MACCORD.

The difference of form is not great in the case of the flanks, but is more conspicuous in the faces, as might be expected from their greater length and more rapid change of curvature. It may, in some cases, be practically inappreciable, but theoretically it always exists; and if the inclination of the axes be great, the wheels small, and the pitch coarse, requiring a comparatively long face to secure a sufficient angle of action, it cannot be neglected without seriously impairing the constancy of the velocity ratio in one direction of the rotation.

In order to avoid confusion by the multiplicity of lines, it is advisable in laying out the teeth to make a separate diagram for the determination of each face-surface and each flank-surface, and to combine them afterward, taking care to observe that the face and the flank which belong to the same side of the same tooth are derived from the parts of the curves of intersection which lie on opposite sides of the common element of the pitch-surfaces.

The pitch-surface in Fig. 9 is the smaller of the two shown in Fig. 3, and in Fig. 13 we have shown on a larger scale the results of following out the instructions above given. In the lower part of this figure are seen the generatrix, *d b*, of the pitch-surface, and also those parts of the curves of intersection used in finding the flank-traces for the direction of rotation shown in Fig. 9, the flank-traces themselves, the face-traces for the same side of the tooth, and the parts of

the curves of intersection from which they were derived; all being seen from above, as in the top view of Fig. 9.

In the upper part of the figure the appearance of the complete teeth is shown, the wheel being viewed from the smaller end. The long tooth on the right is continued till cut by the gorge plane of the pitch-surface; the shorter ones on the left are limited by the inner normal cone, shown in dotted lines in Fig. 9.

The curves used in constructing the other side of the tooth are omitted, in order to avoid confusion; but it may be stated that Fig. 13 is an accurate copy of a drawing carefully constructed on a large scale, in exact accordance with the methods of procedure above set forth.

Now, in regard to the pitch of the teeth, there appears at first sight to be a contradictory state of things. For, referring to Fig. 3, it will be seen that the ratio of the velocities is not the same as that between the radii of any two circles on the pitch-surfaces which have a common point, as, for instance, the gorge circles or the upper bases; and again, the ratio of the radii of such circles varies with their distance from the gorge planes.

But notwithstanding, since the velocity ratio is constant, it must necessarily happen that if any two such circles be divided, starting at their common point, into numbers of equal parts inversely proportional to their angular velocities, the points of division will come successively into contact as the rotation progresses. We may, therefore, as in spur or bevel gearing, assume any pitch we please, divide the pitch circles, or bases of the frustum, accordingly, and then bisect the pitch arcs, making the teeth and spaces of the same size. Then, supposing absolute perfection of workmanship to be attainable, the wheels thus made would gear together without any back-lash whatever; and the amount which must practically be allowed will depend entirely upon how nearly perfect the workmanship actually is.

Having decided upon the pitch, the next thing is to determine how far the tooth shall project beyond the pitch-surface, and how deep the space must be within the pitch-surface. The principles here involved, also, may be made clearer by reference to Fig. 7, where it will be seen that from the mode of generation, the point of contact of the two curves must always lie in the circumference of the describing circle; or, supposing the system to have sensible thickness, the line of contact of the teeth must lie in the describing surface.

In that figure the action begins at p, ending at a, the wheel, c, meantime turning through the angle, $p\ c\ b$; it takes place between the face, $b\ a$, of one wheel and the flank, $g\ a$, of the other, and is confined wholly to one side of the line of contact of the pitch-surfaces. If the angle, $p\ c\ b$, be assumed, the height of the tooth, beginning at b, is limited by its intersection with the describing circle at a; then making the arc, $p\ g$, equal to the arc, $p\ b$, we have $g\ a$ as the acting depth of the flank of the tooth of the upper wheel.

Conversely, if we assume the height, $p\ r$, and describe through r an arc about c, cutting the describing circle in a, the angle, $r\ c\ a$, will obviously be equal to $p\ c\ b$; and then a circle through a, about center, d, will cut the flank-curve, $p\ o$, in the point, o, and determine its acting depth. The face and flank required to complete the teeth are of course to be generated by another describing circle on the opposite side of p. By an operation similar to the above, we determine the lengths of those curves and the angles of action on the other side of the line of contact of the pitch-surfaces. Thus the total length of the tooth, and the whole angle of action due to it, in the case of either wheel, is readily found; the latter, it need hardly be said, must, in any kind of gearing, be at least equal to the pitch, as otherwise one pair of teeth would cease to act before the next pair began; and it should be considerably greater.

The application of this principle to the case in hand is shown in Fig. 14, where D is the axis of a wheel, supposed perpendicular to the paper, the circle, $p\ k\ l$, being the base of the normal cone. Let $p\ e$ be the projection of the element of contact of the pitch and describing hyperboloids, $p\ a\ x$ the intersection of the latter with the normal cone, and $p\ r\ t$ the trace of the tooth-surface. If we assume $p\ D\ b$ as the angle of action between this face and the flank with which it is to work, we have only to draw $b\ a$ similar to $p\ r\ t$, cutting $p\ x$ at a, which will limit the height of the tooth. Or, if we assume r as that limit, the arc about D, through r, will cut $p\ x$ at a, giving $r\ D\ a = p\ D\ b$, the angle of action between this face and the flank of the other wheel.

Let C be the axis of that wheel, also perpendicular to the paper; $p'\ e'$, the projection of the element of tangency, $p'\ z$ the trace, on the cone generated by the same normal, of the same describing hyperboloid, and $p'\ s$ that of the flank-surface. Now, the turning of D, through the angle, $p\ D\ b$, causes the describing hyperboloid to rotate through a known angle; and by the method illustrated in Fig. 9 we can ascertain the point, a' in $p\ z$, which corresponds to that angular motion. Then an arc through a' about C will cut $p'\ s$ in the point, o, which thus limits the acting depth of the flank. Or, otherwise, the rotation of D through the angle, $p\ D\ b$, causes the rotation of C through a known angle, $p'\ C\ g$; whence, drawing from g a curve similar to $p'\ s$, cutting $p'\ z$, we may determine a' and o without reference to the rotation of the describing surface. But it is to be noted that the point, o, does not limit the depth of the space, which, in order to permit the passage of the tooth of the other wheel, must extend within the pitch-surface a little farther than the face of that tooth projects beyond its own pitch hyperboloid. The same process is to be repeated with respect to the face of the tooth of C and the flank of that belonging to D, which will complete this operation and enable us to ascertain exactly the whole angle of action of each wheel.

It is next to be observed that when the highest point, r, for instance, of the tooth, is determined, the position of the element passing through it is fixed. Now that element, in its revolution about the fixed axis of the pitch-surface, will generate another hyperboloid, and the blank for the wheel should be made in the form of a frustum of that surface. For, if it be not, the teeth will begin and end their action at a single point, instead of coming at once into contact along a line, the obvious tendency being to cause abrasion, especially at the points of the teeth of the follower, which are first acted on by the flanks of the driver.

If the wheels are located at or in the immediate neighborhood of the gorge planes, the hyperbolic outline must be accurately constructed and carefully followed in making the blank, in order to avoid this difficulty.

But the hyperbola is a curve which becomes very flat at a short distance from the vertex, so that if the wheels are not very near the gorge circles, it will ordinarily suffice in practice to use a frustum of a cone tangent to this external hyperboloid, terminated, as before, by cones normal to the pitch-surface.

This is shown in Fig. 15, where A B is the axis, and the dotted curve, R S T, is the outline of the pitch-surface, to which the cones, V E N, Y H P, are normal. Supposing the outer element of the tooth-surface to have been found as above, let C D be its projection in this view, and C G its least distance from the axis; then G H E will be the hyperbolic outline of the blank, to which C D is one asymptote, and C K, the companion generatrix, is the other. The limiting cones cut the blank in the circles here seen edgewise as N E, P H. If H be far from G, the curvature of H E will be slight; bisect it at I, draw I F parallel to D C, cutting C K in F. Set off F L = C F, and draw I L, which will be tangent to the hyperbola at I; then producing I L to cut A B in M, this point will be the vertex of a cone tangent to the external hyperboloid round the circle described by the point, I, and practically coinciding with it throughout the zone, N H.

A describing hyperboloid, whose angular velocity is to that of the pitch-surface as 2 to 1, was selected as corresponding to the use in spur gearing of a describing circle half as large as the pitch circle, which makes the flanks radial planes, the teeth being therefore weak at the root. Fig. 13 shows that in this case the result is even worse, and that if strength be an object, a still smaller describing hyperboloid should be employed. The effect of this is seen in Fig. 16, which represents the wheel formed from the larger pitch-surface of Fig. 3, designed to gear with the one shown in Fig. 13; the velocity ratio is as 3 to 2, the smaller wheel having 18 teeth, the larger 27. Since the same describing surface is used for both, its angular velocity is to that of the larger pitch-surface as 3 to 1.

Unquestionably, these wheels, like all others, will have a better action if the teeth be small and numerous, than if they be few and large. And if laid out by some of the approximate methods with which we have met, it is necessary that the teeth shall be of fine pitch, in order to secure any reasonable degree of smoothness in action. But it is not always possible to use teeth of fine pitch, because they may be too weak for the work, and we have known the attempt to construct these wheels to be abandoned when their use was desirable, solely because the teeth, when laid out by those approximate methods under the conditions imposed by the nature of the case, would not work at all.

It is not to be pretended that this kind of gearing can be used in all cases to advantage; but Figs. 13 and 16 show the actual results of applying the methods explained, to a case which might arise in practice. These processes are not approximate, but theoretically correct throughout, so that had it been necessary to increase the pitch, and consequently the length of the teeth, it could have been done without the risk of failure, and without impairing the constancy of the velocity ratio in either direction. The pronounced difference between the fronts and backs of the teeth, as seen in the larger wheel, a peculiarity not pointed out by previous writers to our knowledge, is of itself sufficient to show that this result could not be attained by any process which ignores that difference; and we have never seen any instructions for laying out these teeth in which it is even hinted at.

The case selected for illustration is one in which the projections of the axes, on a plane parallel to both, intersect obliquely. This case admits of another solution, and when those projections intersect at right angles, it will be found that the pitch-surfaces have a very curious relation to each other, being tangent, not along one line only, but along two rectilinear elements. These, with some other noteworthy matters relating to the subject, will be treated of in another article.

THE GALVANIZING PROCESS.

SOME FACTS OF INTEREST CONCERNING ZINCKED IRON AND THE PROCESS OF GALVANIZING.

THE surfaces of various objects of iron that are intended to be exposed to the action of the atmosphere, must be carefully protected in order to retard or prevent their rapid oxidation and destruction. This is accomplished either by a coating of some paint, or by covering the surfaces with a film of oxide (as in certain lately patented processes that have attracted much attention), or more commonly by giving the iron a superficial covering of some metal which is less susceptible to atmospheric influences. It is with these last named operations that we are here interested, and especially with the process known as galvanizing, *i. e.*, covering iron surfaces with zinc.

The general details of this operation will be described hereinafter, but a few preliminary remarks in explanation of the protective action which zinc exerts under such circumstances will be useful.

The protection afforded to iron by a zinc covering is mainly the same as that afforded by a paint or other coating, a purely mechanical one—due to the interposition of an indifferent surface between the iron and the atmosphere. But this is not all. The protection afforded by zinc is in an important sense a chemical one also, and as we shall shortly see, upon this fact depends not only the justification of the term "galvanized" iron, which is applied to iron thus coated, but also the great difference in the behavior of tinned iron as compared with zincked iron, and the superiority of the last named as a protector of iron.

It is a well established fact that when two metallic surfaces are brought into contact with each other, in the presence of a liquid capable of acting chemically upon either of them, all the conditions necessary for the generation of an electrical current are present. The metals and the liquid excitant constitute, under these circumstances, a galvanic element, and the electro-positive metal of the couple is dissolved, or oxidized, or otherwise chemically affected with greater rapidity and eagerness by the existing liquid, than would be the case if it were simply immersed in the liquid without contact with the other metal.

These facts explain the very rapid corrosion of tinned iron if left unprotected by paint, by atmospheric influences, and the much greater indifference displayed by zincked or galvanized iron under the same circumstances. The reason will be clear from the following:

It is impossible in practice to secure a *perfect* coating of either zinc or tin upon iron. There will be defective spots where the coating is not perfectly adherent, and at such points and along the edges where the sheet has been cut, the penetration of moisture at once sets up the very conditions for the generation of localized galvanic currents, and for the rapid chemical corrosion of the positive metal that has just been described.

Let us see now what are the consequences with tinned and zincked iron under these circumstances.

Arranged according to their electro-chemical qualities, and beginning with the ones which will be the most electro-positive (*i. e.*, the most readily attacked or corroded), these metals will stand in the following order—zinc, iron, tin.

Wherever now the surface coating of tinned iron is imperfect and the moisture gains access to these defective portions, a rapid electro-chemical action is set up, and the iron being the electro-positive element, is energetically oxidized; and let it be borne in mind, more energetically than if it were not in contact with the tin. Wherever a tinned plate begins to go, it will rust far more rapidly than an unprotected iron surface exposed to the same conditions. With zincked iron the case is very different. Wherever the zincked surface is broken or defective, an electro-chemical action is set up by the contact of moisture, but from the fact that differences in the electrical character of these metals is much less decided than with tin and iron, the excitation is very feeble, and the rapidity and energy of the chemical action resulting therefrom are correspondingly feeble, and the action is essentially different; for while in the case of tinned iron we have seen that the iron is corroded at the expense of the tin, since the last is the electro-negative element, in the case of zincked iron it is the iron which is the negative element, and when chemical action is set up at the defective or exposed surface, it is the zinc that suffers the corrosion, not the iron, and from the very feeble electrical current which a zinc iron couple is capable of generating, this action is much less energetic than in the case of tinned iron. This explains why defective long exposed tinned sheets are covered with patches of iron rust, while long exposed and defective zincked (or galvanized iron) shows no signs of it, but shows the whitish incrustation of zinc oxide instead. The superiority of zincking over tinning as a mode of protecting iron surfaces against rusting, is, therefore, due to something more than the mere mechanical protection of the coating.

The coating of iron with zinc or tin is generally supposed to be a simple operation, but it is far from being so, requiring a number of successive operations, all of which demand skill and experience to succeed properly. The mere dipping of the iron in the bath of molten zinc—to confine ourselves to galvanizing—is the last and simplest step of the process. It is the preparatory steps that are the most important, and the most tedious and difficult.

The all-important thing for the galvanizer is to properly prepare the surface of his iron to take the zinc. The iron must be clean of oxide, cinder, sand, or other impurity, or the zinc will not adhere—not clean in the general acceptation of that term, but chemically clean, which is a very different matter. A piece of iron may look clean to the eye, but the galvanizer knows full well that the eye is not to be relied on in judging of this, for it may come from the zinc looking very much as if one had taken a handful of black dirt and scattered on it. The zinc has found the imperfections that were imperceptible to the eye, and the galvanizer, knowing this fact, subjects every piece of iron, before he will trust it to the tender mercies of the zinc, to the process of chemical cleansing called "pickling." This pickling is performed in large wooden or lead lined tanks, troughs wherein the iron objects are left in contact with diluted sulphuric acid for a period varying from 6 to 24 hours, according to the quality of the iron, and the amount of scale, cinder, etc., that it carries.

From the pickle the iron goes into clean water to remove the adhering acid, and from the water the pieces are removed one by one for examination. This step of the operation is very important to remove all remaining patches of scale, etc., that may have withstood the action of the pickle, and is effected by means of brush and sand locally applied, or with obstinate patches by a steel scraper, or even by filing. From this operation the iron goes into a bath of commercial muriatic acid. This step is made necessary because the clean skin of the iron left by the pickle is so sensitive to the atmosphere that, on being taken from the water, it is almost instantly covered with a film of oxide. If dipped in this condition, a very considerable amount of flux (sal ammoniac is generally used) would be required to remove this oxide before the zinc would take, and to avoid this, which would entail considerable delay in the zincking, to say nothing of the expense for flux, the oxide just spoken of is instantly removed by immersing the iron in the muriatic acid bath. The acid is allowed to drain off, and the iron, still moist with it, is conveyed at once to a drying oven and is then ready for zincking. The appearance of the iron after this final treatment is peculiar, as the action of the residual muriatic acid has speckled the surface with innumerable little white spots of chloride of iron, which suffice to protect the iron against further oxidation, and being itself a flux, is readily dissolved off without use of more than the ordinary quantity of sal ammoniac, which is thrown on the zinc from time to time to prevent excessive loss of zinc by volatilization, and to gather together such impurities as gradually accumulate on the surface of the bath. The zinc is melted in large iron tanks capable of holding from about 5 to 20 tons of metal, and which are set in such a manner as to secure the heat of the fire about the sides as well as the bottom.

The temperature of the metal is of great importance to the successful conduct of the operation. The best results are obtained with a clean bath heated to about 740° Fahr. Should the heat much exceed this temperature, the iron will be too violently attacked by the zinc. If the heat be too low, the opposite evil is encountered.

In connection with the process of galvanizing just described, it will be of interest to notice certain facts on which the books are silent, but which are of vital importance to the commercial success of the operation.

As may be gleaned from the foregoing description, the operation of galvanizing is both tedious and disagreeable. It is more than that; it is exceedingly crude and wasteful. With wrought iron (sheet iron is here mainly referred to) the pickling is rapidly effected, as the iron is comparatively pure and the adhesion of the zinc is readily effected, the time of immersion in the molten metal being about a minute to a minute and a half to a sheet. One man seizes a sheet by the broad side, allows it to enter the bath vertically (or edge first), then allowing it to remain quietly for an instant, directs it by means of an iron tongs beneath a bridge wall of fire brick which stretches longitudinally across the bath, thus requiring the sheets to be passed beneath the metal to reach the other side of the bridge. So soon as the sheet emerges from beneath the bridge, the workman on the other side seizes it and slowly removes it from the bath. The scum and dirt are brushed from the surface, and if found to be free from spots and properly coated, it is passed, and so the operation continues, two men at the bath being able to galvanize from 400 to 500 sheets per day of ten hours. The sheets, after being properly cleaned of adhering scum by wiping with a cloth, are passed by other workmen through a set of rolls by which any irregularities of the surface are removed, the adherence of the zinc increased, and the surface generally improved in appearance. The beautifully mottled appearance presented by sheet iron properly galvanized is not brought about, as is sometimes erroneously asserted, by a subsequent dipping in a bath of acid, but is produced by the crystallization of the zinc, due to the rapid

cooling of the piece, and will be found to characterize all objects of iron whose mass is so disposed or whose surfaces are so extended as to favor speedy cooling. Heavy objects, castings, and the like generally show a uniform gray mottled surface of zinc, as the mass of metal loses its heat too slowly to permit of the zinc coating becoming crystalline.

Cast iron presents many more difficulties to the galvanizer than wrought iron.

The surfaces of all castings are more or less covered with cinder and sand from the mould, and where the quality of the castings is inferior, as happens to be the case with much of this work that is sent to the galvanizer, the condition of the surface is such that immersion in the common pickling bath of diluted sulphuric acid, even for a considerable time, does not suffice to obtain a clean surface. In a few cases, therefore, it becomes necessary to use strong oil of vitriol for the common pickle, and even after coming out of this, they often show obstinate patches of scale or other impurity, which must be removed by the file before the piece is ready for the bath.

With cast iron, however, no matter how good its quality, the zincking operation is by no means so rapidly accomplished as with wrought iron; and according to quality, the pieces require from 5 or 10 minutes to a half an hour, or even longer, of immersion in the zinc before a proper coating is obtained. The chief cause of complaint with the galvanizer, however, and that which entails upon him a heavy annual expense, lies in the formation of what is called "dross" in the zinc bath

How this originates will be apparent in a few lines. Zinc and iron alloy only with great difficulty; in fact, by bringing the two metals together in the state of fusion, as is the common practice in forming metallic alloys, the production of an alloy is found to be practically impossible, owing not entirely to the want of affinity between them, but mainly to the fact that the zinc will volatilize so rapidly and completely at the temperature of the molten iron, that a union of the two metals in the ordinary way is not practicable. By immersing pieces or fragments of iron in melted zinc, however, a gradual solution of the metal will in time take place, and a zinc-iron alloy will be produced. This is precisely what occurs in the operation of galvanizing. Before the actual adherence of the zinc to the iron objects immersed in the bath takes place, a certain quantity of the iron is dissolved away and enters the zinc bath. The quantity dissolved off of each piece is of course very trifling, but after the dipping of many hundreds of iron pieces, which will be done in a day, the aggregate of dissolved iron will become considerable. This fact of itself might not be considered objectionable, were it not that this alloy thus accumulating in the bath speedily renders it quite unfit for galvanizing.

This alloy, from recent investigations, appears to have a definite constitution, in which the rates of iron to zinc is as 1 : 22, and contains in 100 parts, according to analysis, 96·4 per cent. of zinc and 3·6 per cent. of iron. It is heavier than zinc (sp. gr. = 7·06; pure zinc = 6·86), and gradually sinks to the bottom of the bath, and it has a much higher point of fusion.

In the manner above described this alloy rapidly forms in the bath, and as the heat of the bath must be carefully kept down to avoid the too energetic action of the zinc, the alloy is left below its point of fusion, and gradually aggregates in granular particles, and accumulates at the bottom of the bath, carrying along with it whatever oxide and other impurities there may be formed, and forms a mass, more or less spongy in texture, according to the quantity of these impurities that may have been carried down with it. This is known as the "dross."

The settling of this "dross" will only take place after the metal has been left quiet for some time, but as it accumulates the activity of the zinc rapidly diminishes, the work produced becomes inferior, so that it becomes necessary from time to time to remove it. This operation is called "drossing," and is usually done about once a week. An iron ladle, with numerous perforations to permit the liquid zinc to run off, is used for the purpose, and the dross, in slabs of nearly a hundredweight each, is disposed of to the smelter and refiner, or, as is the case in some establishments, is refined at the works. This "dross" when sold to the refiner, who usually gains the zinc by distillation, brings about one-half the price of the commercial zinc, and therefore represents a loss to the galvanizer of from 2 to 3 cents per pound. The quantity of "dross" formed in the galvanizing operation is simply enormous, amounting in baths of very moderate size to as much as 1½ to 2 tons or even more per week; and when it is considered that in some large establishments three or four large baths are in constant operation, the extent of the loss from this source becomes apparent, amounting to hundreds of dollars weekly.

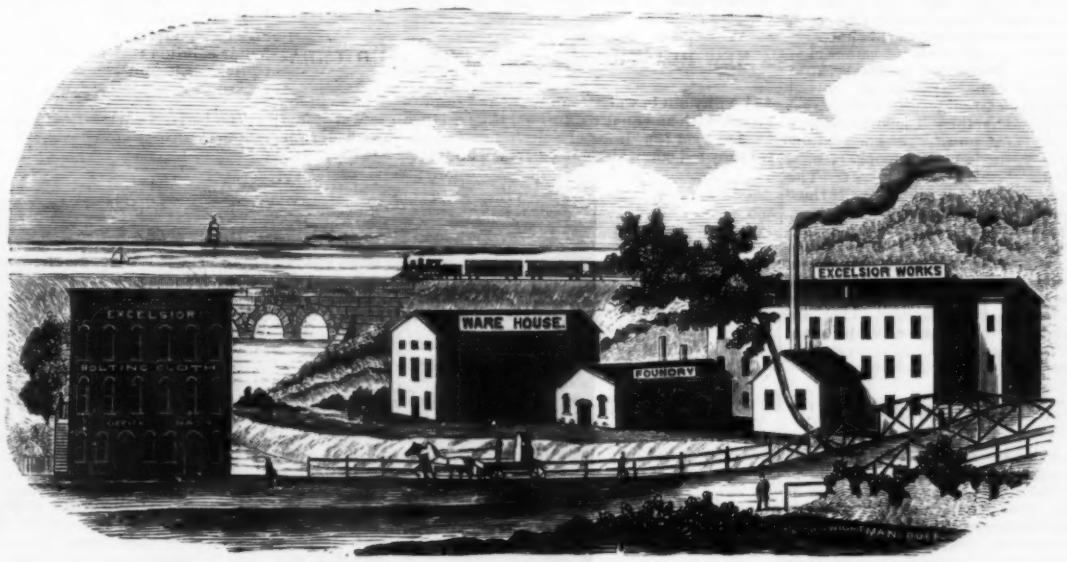
Thus far no effectual mode of obviating this grave difficulty has been discovered, no means being known either whereby the formation of the dross may be prevented, or the purification of the bath effected; and this, in spite of the fact that numerous plans and experiments for the solution of the problem have been tried. The present practice, as above remarked, is to "dross" the baths at weekly or more frequent intervals, and to refine the zinc by distillation or otherwise. As this operation requires special apparatus and skilled attendance, the galvanizers rarely do the work themselves, but sell the dross to the refiner and smelter at a fixed price, from whom they get back their zinc refined.

Several modes of refining the "dross" other than by distillation are practiced, but none give very satisfactory results. One mode, for example, depends upon a separation by simple gravitation. The dross is melted in a pot with the addition of a considerable percentage (from 10 to 25 per cent.) of commercial zinc, to increase its fusibility, the oxides and other dirt rising to the surface are removed, the temperature is raised to nearly the point of volatilization, and the metal allowed to quietly cool. In this manner it is claimed the major portion of the iron will shortly find itself in the lower portion of the metal, while the upper part is comparatively free from it, and is removed from time to time and run into ingots, but not, it is strongly suspected, before having received first another dose of pure zinc to render it merchantable.

Another mode which is practiced to a limited extent, is founded on the well-known fact of the want of affinity of zinc for sulphur, and the readiness with which this agent will attack most other metals. The mode of operating this process is about as follows: The "dross" is melted in an iron vessel with the addition of sufficient pure zinc to render fusion easy, the temperature is raised almost to the point of commencing volatilization of the zinc, and then by means of an inverted perforated spoon or other suitable device, a quantity of sulphur is brought under the surface of the metal and stirred about to insure contact of the agent with all parts of the same. The sulphur speedily vaporizes, and the vapors escaping find their way through the "dross" and take out the iron, lead, and other impurities. This is the theory, but in practice the operation is by no means so perfect. A certain percentage of the iron may certainly be taken out in this way, but a notable percentage still remains in the dross, defying all efforts to remove it. Again the loss of zinc in this operation detracts from its value, and this loss cannot be avoided, as the action of the sulphur on the iron and other impurities of the "dross" will only take place at a temperature close on to that at which the zinc begins to volatilize. The chemical action of the sulphur and the combustion of the vapors that reach the surface of the bath unchanged, liberate sufficient heat to locally fire the zinc, while considerable must be lost by simple volatilization. Still the operation is practiced in a limited way, though its success may be asserted with tolerable certainty to depend, as in the gravitation method above described, as much in "watering the stock" with pure zinc, as in the merits of the sulphur treatment.

The only effectual mode of treating the galvanizer's "dross," it may safely be asserted, is by the process of distillation, by which operation, as is well known, the zinc can be obtained almost chemically pure.

We may be prepared in a subsequent article to offer some suggestions as to the manner of obviating these crudities and defects in the current practice of galvanizing.



"EXCELSIOR" WORKS, SILVER CREEK, NEW YORK.

"EXCELSIOR."

HUNTLEY, HOLCOMB & HEINE, SILVER CREEK, N. Y.

THE following interesting paper is from the *St. Louis Miller:*

Leaving Buffalo at 12:55 P.M., via Lake Shore and Michigan Southern Railway, after a thirty miles ride, the locomotive blows for a stop and the brakeman sings out "Silver Creek." This name, peculiarly suggestive under recent congressional legislation, always had something attractive and charming to mill men; for who that wears the dusty suit, or watches the grain market, has not heard of Silver Creek in connection with the various machines used for milling purposes made there?

Speeding through a narrow pass, cut out of solid rock, there opens before us a beautiful valley, to cross which the L. S. & M. S. R. R. Co. have, at an expense of half a million dollars, built up two single and one double arch, and thrown up earthworks. Here, to our right, is Lake Erie and the Canada shore in the distance, to our left, in the valley, is Silver Creek—a most beautiful place. Soon the train stops, and we alight at a commodious depot, where a 'bus in waiting takes us down town. It is our business to call at the Excelsior Works, and the obliging "'bus man" lands us safely at the office of Huntley, Holcomb & Heine, where we are cordially met by the gentlemanly members of that firm.

During late years this firm has become familiar to every miller in the land, and the excelsior bran duster, the excelsior middlings purifier, or the excelsior anchor bolting cloth, are household words among the knights of the pick. Few indeed are the mills where some of these goods are not found, and few are the establishments that do so prosperous a business as Huntley, Holcomb & Heine; and when we ask ourselves for the secret of their great success, we find the answer in these words · *genius, perseverance, and integrity.*

It was a small beginning indeed that recorded the sale of one bran duster the first year. Those who can look back to 1858 can well remember that in those days to talk bran duster was to arouse suspicion that you might be an impostor, the various contrivances offered under that name, up to that time, having failed in almost every instance.

Notwithstanding this, Mr. W. W. Huntley conceived the idea that if there was any flour left in the bran after passing through all the ordinary bolting processes, it might be saved, provided the machine used for the purpose was not so complicated as to render it obnoxious to the miller using it. Discarding all former plans of dusting bran in a horizontal revolving cylinder, or on a horizontal disk, and applying the law of gravitation, he built a vertical bran duster, with a stationary cylinder and revolving adjustable brushes, and he called it the excelsior bran duster. This first machine worked well, but it was a whole year before another was sold, and it took seven years, during which time Mr. Huntley associated himself with Mr. A. Babcock, before the business could be considered established.

However, there were clouds ahead. In 1865 a patent ring was formed, who claimed a royalty from those using the excelsior bran duster. Suit was brought, and Messrs. Huntley and Babcock promptly met the ring and defended their customers. After a tedious and expensive litigation, extending over two years and costing nearly $10,000, the ring was defeated. The promptness with which H. & B. had protected their customers gained for them confidence, and this, with the good report of the work of the excelsior bran duster made by those using it, rendered it the most popular machine of the kind in the country.

In 1871, Mr. Huntley associated with himself Mr. A. P. Holcomb, having previously (in 1869) severed his business relations with Mr. Babcock. Mr. Holcomb is a manufacturer and inventor of twenty-four years' standing, having been engaged in various manufacturing enterprises, and lastly as senior partner of the Springfield (Mo.) Iron Works.

Early in 1872, when the purifier business began to attract the attention of mill men, Messrs. Huntley & Holcomb put their inventive genius to work and invented the excelsior disintegrating middlings purifier, starting out in an entirely new departure, which is covered by their patent on their disintegrating process, covering the feature of taking from the middlings the finest dust and fiber before passing them to the sieves for screening.

In the fall of 1872 a third partner was added to the firm, in the person of Mr. August Heine, a hardware merchant. When this union of three H's was effected it was called one of the most promising firms, and surely events have justified the remark. The demand for purifiers was so great that a new shop, larger than the original bran duster shop, had to be erected by the side of it. In 1874 a new foundry and office had to be built, and a large warehouse soon followed.

The enterprise of the firm did not stop here. A firm from Switzerland manufacturing the most celebrated brand of bolting cloth on the continent, sought a market for their goods in this country, and looking for a reliable enterprising firm, were, by a happy train of circumstances, brought in contact with H., H. & H., who now became the sole importers of the celebrated excelsior anchor bolting cloth, of which it is unnecessary to speak any further than to state that their sales for this cloth have doubled each year, and the indications are that the present year they will run up to $60,000.

Abandoning the old idea of sending out cloths to be made up by operatives, they have erected a three-story brick building, of 50 feet front, occupying the lower floor for their bank and office, and the upper stories for storing and making up bolting cloth. Here they run their sewing machines by steam power, and everything is so nicely and systematically arranged that mistakes in making up cloths are impossible. All this work is done under the immediate supervision of Mr. Holcomb. They keep a full stock of cloth, perhaps the largest in the country, and a full force of operatives. To give an idea with what promptness orders can be filled we will state that a cloth for a 20-foot reel 30 in. diameter, the order for which was received at 10 o'clock A.M., was made and sent off by express at 2 o'clock P.M. of same day, the time required to make it not exceeding three hours. Had any one told us this we would not have believed it, but seeing their improved patented appliances and the many

skilled operatives employed, we can see how it is possible. Millers waiting for a reel make a note of this.

But while H., H. & H. have thus been extending their bolt cloth trade, their manufacturing interest has also been pushed. So that during the past year the Excelsior Works were for a second time enlarged, and a 50-horse power engine, with other labor-saving machinery, added, resulting in their ability to reduce prices in purifiers, as advertised by them.

The firm has recently established a branch house in St. Louis, which is under the charge of Mr. Henry Homberger, and is located at No. 320 South Fifth street. Here the reader will find at all times a complete stock of the Homberger Brothers' celebrated silk anchor bolting cloths, warranted to be the very best of gauzes, and now in exclusive use in many of the most prominent mills. The purifier takes the dust, fine bran and fiber out of the middlings by a patented process before they are passed upon the bolt-cloth sieves, and the manufacturers claim there are no complicated brushing devices or traveling air blast—no roughing up and wearing of bolt cloth by brushers—the sieves are interchangeable, and it is the only machine made under undisputed patents. These bolting cloths and purifier silk grit gauzes took first premiums at Paris in 1867, Vienna 1873, Hallein 1874, Linz 1875, Philadelphia 1876, and St. Louis 1876.

Messrs. Huntley, Holcomb & Heine are all three self-made men, of abundant means and in the prime of life. May they live long to enjoy the fruits of their labors, continue to benefit the milling interest, and prove what genius, perseverance, and integrity will do.

A NEW BLASTING COMPOUND.

A NEW blasting compound, composed of gun cotton and nitrate of baryta, and invented by Mr. J. Ed. Huetter, is now in extensive use in Germany and England. It is especially recommended for mining purposes, as no smoke nor dangerous gases are generated by its explosion.

Moist gun cotton is passed between a series of rollers, by which it is compressed so as to form hard, moist lumps. In order to obtain it in the form of powder, it is now passed through a mill. The powder is, in conical vats, mixed with water containing a little ammonia and caustic soda, so as to form a thin paste. Through the bottom of the vat a current of air is introduced, keeping the entire mass in constant motion. At the same time the temperature is raised to 236° F. by means of steam passed through the mass. After the lapse of three hours the gun cotton has attained a sufficient degree of purity. It is now well washed with pure water, and is now ready for mixing with the nitrate of baryta. The latter salt has, after protracted trials, been found to be the most suitable of all nitrates for this purpose, as it does not only give rise to a minimum of smoke, but also permits the development of the practically greatest force within the smallest space. The materials are mixed in equal proportions. The gun cotton is previously dried in a centrifugal apparatus, and is then passed through a mill together with the nitrate. The powder obtained is now pressed into cartridges. The cartridge press consists of a horizontal iron plate revolving round a vertical shaft. The plate is two feet in diameter, and into its upper surface are sunk round holes corresponding in size to the cartridges. The holes being filled with the powder, the latter is compressed by pistons fitting closely into the holes. The pistons are provided with short, thin stems extending into the center of the compressed mass, and forming the cavities for taking up the fuse. The cakes are now exposed to a current of hot air until they are hardened sufficiently. They are covered with several layers of thick paper, dipped into melted paraffine to protect them against the effects of moisture, and packed for shipment.—*Chemiker Zeitung.*

THE PLANE OF POLARIZATION ELECTRO-MAGNETICALLY ROTATED IN A VAPOR.

IT is known that Faraday did not succeed in proving electro-magnetic rotation of the plane of polarization of light in gases, nor have others succeeded. Considering the interest attaching to this question, Herr Kundt and Herr Röntgen lately thought to repeat the attempt with very strong currents and under the most favorable conditions. The result is that they have been able to prove the rotation at least in the case of sulphide of carbon vapor. Their researches, says *Nature*, have been communicated to the Munich Academy.

Sulphide of carbon was chosen because, on the one hand, it shows a strong electro-magnetic rotation in the liquid state, and on the other, its vapor has a considerable tension, even at low temperatures. An iron tube was used for inclosure and heating of the substance; it was closed at the two ends with glass plates 1 cm. thick, and itself inclosed in a tin-plate tube; so that steam could be led between the tubes to heat the inner tube throughout to 100°. The outer tube was surrounded by six large wire coils, each having 400 windings of wire 3 mm. thick, through which was passed the current from sixty-four large Bunsen elements. A little sulphide of carbon was introduced into the inner tube, and the air having been driven out by vapor forming at ordinary temperature, the tube was closed and fixed in position, and steam was sent through the space around it.

When the whole tube had taken the temperature of boiling water the glass plates and the sulphide of carbon vapor within became quite transparent. A beam of light rectilinearly polarized by a Nicol was now sent through, and a Nicol at the other end extinguished it. The current of the sixty-four elements being now allowed to flow, a distinct brightening of the field was observed. The brightening became still greater when, after closing the circuit, the foremost Nicol was turned to darkness, and the current then reversed with a commutator. The rotation of the plane of polarization occurred, as was to be expected, in the direction in which the positive current passed through the wire coils.

To test whether the rotation might not be due wholly or in part to the glass plates closing the inner tube, the experiment was made without any sulphide of carbon in this tube. A weak rotation, due to the glass, was indeed observed, much smaller than in the other case. To avoid this, however, as much as possible, the wire coils next the glass plates were shut out from the circuit. The four coils now traversed by the current were so far from the plates that their influence must have been very small, indeed the plates then gave no perceptible rotation. Sulphide of carbon having been again admitted, and the experiment repeated, there was a well-marked brightening as before when the current passed. The amount was roughly estimated at half a degree.

It is thus proved that saturated sulphide of carbon vapor at about 100°, in the magnetic field, rotates the plane of polarization of light.

Sulphuric ether was tried in the same way, but gave no effect.

The authors consider it can hardly be doubted that, with suitable arrangements, the rotation may be demonstrated in the case of unsaturated vapors and gases. They are engaged in making an apparatus which will enable them to examine permanent gases at very high pressures in the magnetic field, in order to prove the rotation in their case, and, if possible, to measure the phenomenon. "It would be specially interesting," they remark, "to ascertain whether oxygen rotates the plane of polarization in the same direction as the other gases."

NEW MODE OF TREATING CAOUTCHOUC.

To make caoutchouc indifferent to the action of oils and fats without impairing the other properties of vulcanized rubber, the following method is employed at the works of C. Schwanitz, Jr., at Berlin:

The caoutchouc is worked by heated rollers together, with a mixture of 6 pounds of prepared chalk, 1 pound of glycerine of 1·23 sp. gr., 1¼ oz. of litharge, and 3½ oz. of sulphur. For vulcanizing the mass or the article formed thereof is placed in a bath of glycerine, and exposed to a steam pressure of from two to three athmospheres.—*Deutsche Gewerbe Zeitung.*

NOTE ON HÆMOCYANINE.

HÆMOCYANINE is the name given to a new substance obtained from the blood of the devil fish, *Octopus vulgaris.* The liquid portion of the blood of this animal contains an albuminous liquid substance which forms with oxygen a stable compound of a dark blue color. In vacuo, by contact with living tissue, or when kept in closed vessels, dissociation and generation of oxygen ensue. This substance seems to perform the part of the hæmoglobin in the blood of warm-blooded animals. It is evaded with oxygen in the respiratory organs of the animal, carries it through the arterial system into the capillaries and tissues. The venous blood of the octopus is colorless, the arterial blood dark blue. These changes of color are the consequences of respiration. On laying open the main artery of the head, we find the blood circulating through the same to be blue as long as the animal breathes under water. As soon as taken out of the water the blood loses its color at once. Hæmocyanine may be easily obtained from the blood by dialyzing the plasm formed by the blood for three or four days. Hereby the salts and other diffusible substances are removed. The remaining liquor is filtered and evaporated, whereby the hæmocyanine is obtained as a blue, gelatinous mass.—*Comptes Rendus.*

A NEW REACTION OF CREATININE AND CREATINE.

A VERY dilute watery solution of nitro-prusside of sodium, mixed with an equally dilute solution of creatinine, acquires treated by a few drops of solution of caustic soda, a beautiful ruby red color, changing after a while into a straw yellow. This test is very sensitive. The reaction may be used for proving the presence of creatinine in urine, as no other substance so far found in urine behaves similarly. As creatine may be easily converted into creatinine, the former also may be detected by this agent, provided both substances do not accompany each other.—*Ber. der Chem. Gesell.*

RELATIVE CHEMICAL ENERGY OF SUNLIGHT, ELECTRIC LIGHT, AND MAGNESIUM LIGHT.

IN a second paper, read at a meeting of the American Chemical Society, March 5th, Prof. Leeds gave the results of the continuation of his experiments upon the measurement of actinic forces by means of soluble iodides. In the former measurement of the action of the sun's rays (Jan. 23d and 24th, 1879), the iodine set free entered into combination with starch; the iodide of starch thus formed becoming very faint rose, faint rose, rose, violet, blue, and intense blue as the liberation of iodine went on. It had been supposed that the formation of the insoluble iodide of starch facilitated the decomposition, but this is not the case, as the following experiment shows. Six comparison tubes were taken, into three of which 5 c.c. of starch water were introduced, and all filled up to 100 c.c. with distilled water. Into each of the three without starch 1 c.c. of sulphuric acid was placed. To the first, 1 c.c. of potassium iodide of 10 per cent. was added; to the second, 1 c.c. cadmium iodide; to the third, 1 c.c. lithium iodide. The three with starch were similarly prepared. They were exposed to the sunlight, February 15th, from 10:30 A.M. to 12:45 M., when the first solution contained 7·5 mgrms. free iodine; the second, 8·2 mgrms.; the third, 5·8 mgrms. The corresponding solutions with starch contained only 3·70, 4·0, and 3·75 mgrms. of iodine respectively, or about one-half the former quantities. As a consequence the use of starch was abandoned, the increase in the amounts of iodine set free being indicated to the eye by the deepening of the yellow color in the solution.

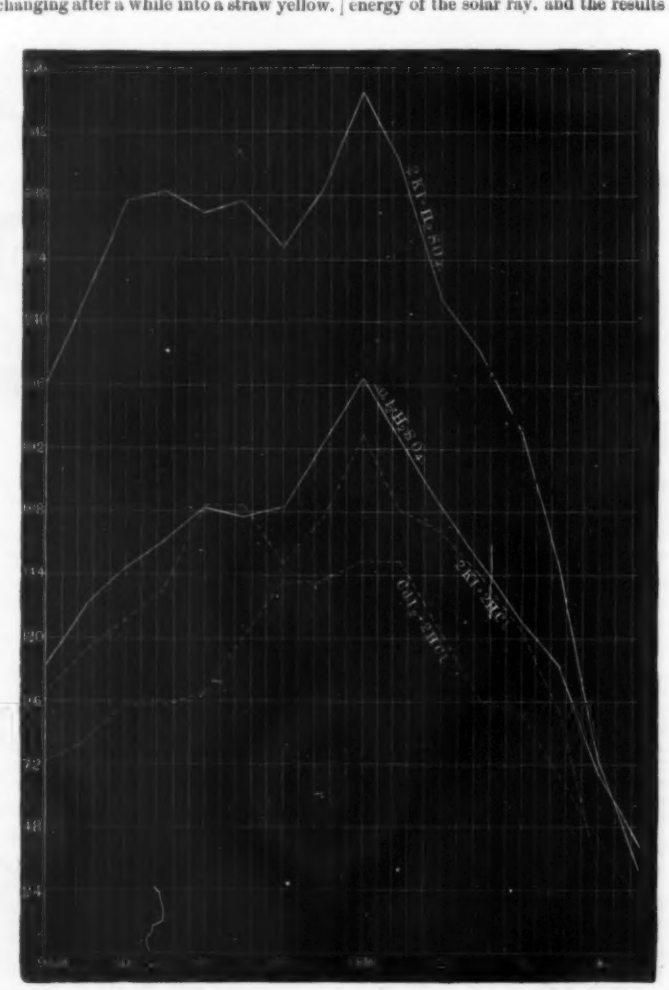
Nor was this effect limited to the mineral acids alone: the organic acids, oxalic, tartaric, and acetic, also exhibited it; the amount of decomposition, however, being by far the greatest in case of the first of the three acids mentioned.

Without detailing the experiments by which this was shown, it was established that in every instance the presence of air or oxygen is essential to the decomposition of the iodides under these circumstances. In the dark, also, decomposition very slowly occurs in case air be not excluded, and that, too, however dilute may be the solutions. But in the strongest sunlight, the solutions may be exposed for days without change, if the air be entirely removed by a current of carbonic acid. If, under like circumstances, the carbonic acid be replaced by pure oxygen, the iodine set free greatly exceeds the amounts liberated in presence of air only.

It has been established, also, that in the entire absence of air, the dilute iodides may be heated along with acids at a temperature of 221° F. for a number of hours without undergoing decomposition, while similar solutions heated to the same temperature in contact with air are rapidly decomposed. With these explanations, the experiments detailed below will be more readily understood. The acids used were some specially prepared for the purpose, and were of such strength that 1 c.c. of the sulphuric was equivalent to 25 c.c. of a standard soda solution, 1 c.c. of the hydrochloric to 10·7 c.c., and 1 c.c. of the nitric acid to 12·6 c.c. The potassium iodide solution was of 20 per cent.; the other iodides were equivalent to half this amount of potassium iodide.

SUNLIGHT.

As a basis of comparison, a new determination was made, on the 27th of February, without starch, of the chemical energy of the solar ray, and the results are given in the accompanying diagram. The numbers in the vertical columns are the amounts of iodine in milligrammes, set free during the corresponding intervals of the day.



ELECTRIC LIGHT.

A cylindrical stand was made of such dimensions that the center of the axis of the 100 c.c. column contained in each comparison tube should be at a distance of 6 in. from the focus of the electric light. The electric arc was taken between carbon points, and was produced by electricity generated with a dynamo-electric machine run by steam power, its illuminating capacity varying during the course of the experiment, according to photometric measurements made by

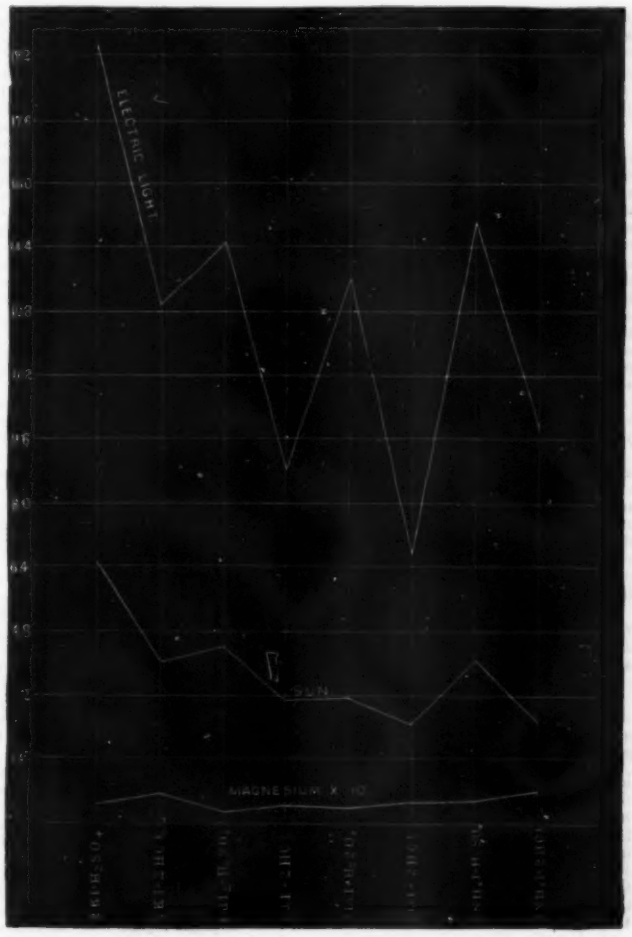
Prof. Morton and Mr. Beckmeyer, between 7,000 and 7,500 candles. In the first experiment, the first 9 solutions contained 5 c.c. starch water, the last none. In the latter the decompositions were twice as great.

MAGNESIUM LIGHT.

The light was furnished by a single-ribbon magnesium lamp, run by clockwork. The reason for repeating the experiment three times was, that the ratio of decomposition in presence of free hydrochloric acid was greater instead of less (as when sun and electric light were employed) than in presence of free sulphuric acid, the acids being of strengths above given. This difference is probably connected with the fact, long since recognized in photography, that the maximum of sensitiveness for certain sensitive salts is located in different parts of the spectrum. The solutions, as in the case of the sun and electric light, were always made up in comparison tubes to 100 c.c.

COMPARISON OF ACTINIC INTENSITIES FOR EQUAL TIMES.

The foregoing results are given in the accompanying diagram, where the numbers found for magnesium light have been multiplied higher, in order that the corresponding line may be brought into the same illustration with the others.



CONCLUSION.

These results tend to show that the chemical energy possessed by various sources of illumination may be a separate feature worthy of especial attention, and that, in this respect, the intense energy of the electric light exalts it far beyond any source of artificial illumination at present time known.

ANALYSIS OF THE ZSADANYER METEORITE.

WILH. PILTZ has analyzed portions of the meteorite found last year near Zsadanyer with the following result: The greater portion of the meteorite did not present a metallic appearance, but contained small metallic grains throughout its entire mass. The earthy portions formed 78·53 per cent, the metallic globules 22·26 per cent.

The composition was found to be the following:

In 100 parts of the—

EARTHY MASS.		METALLIC GLOBULES.	
FeO	15·054	Cu and Sn	2·323
Cr_2O_3	1·276	Mn	6·047
Al_2O_3	3·027	Fe	67·219
MgO	22·343	Ni	10·177
CaO	4·683	Co	Trace
K_2O	5·850	S	9·734
Na_2O	0·421	P	1·658
SiO_2	47·346	C	0·774
		Chrome iron	2·065
	100,000		99·997

—*Ztschr. für analyt. Chem.*

SAFFRON.

To detect adulteration with Calendula flowers (*Feminelle*), it is merely required to moisten a few flowers, and to rub them singly with the finger on white paper. The genuine flowers will give a fine yellow color, whilst the feminelle will only yield a violet reddish hue. It can also be easily detected by soaking the suspicious flowers in pure or, better still, distilled water. The real saffron will retain its fine red color after hours, whilst the feminelle will lose its artificial tint within a short time.

To detect an admixture of honey and barytes it is merely required to put a pinch of saffron in a tumbler with pure clear water (also in this case distilled water is preferable), and agitating it for a few minutes. Adulterated saffron will at once turn the water cloudy, and even small particles of dust may be seen falling to the bottom, which, on pouring the water carefully out, will be found to be a slimy, sand like mass. With pure saffron the water will remain clear, showing a fine pure yellow color, which, according to the quality of the flowers, will be more or less intense. Five or ten minutes suffice for these experiments.—*Chemical News.*

CRYSTALS.

CRYSTALLOGRAPHY.

THIS study has always been neglected by students, and probably always will be, till they lay aside the notion that it is a collection of hard names, and that it is of little importance to them. To pursue its study, it is necessary to consult numerous works that treat upon the subject, in order to get a comprehensive knowledge; few works give it little more than a passing notice, and it is seldom that a student will pick up the fragments and unite them into a beautiful and complete whole.

To save them trouble and time, I will here undertake to put the study in a clear and concise manner, so that it may serve as a guide to a very perfect knowledge of the subject, bearing in mind that the essay is intended for students. It will be made as simple as possible by giving familiar examples when practicable.

As to the manner in which crystals are formed, we are entirely ignorant. Chemists can reproduce very few of them as they are found in nature; they are usually much smaller, and frequently belong to a different system. Take, for example, the crystals of carbonate of lime found in nature. These are large, while those produced in the laboratory are microscopical in their character. The diamond—crystallized carbon—science has not yet reproduced. The formation of crystals relies not upon chance; they are as definite as the leaf or flower of a plant; yet, while botany is frequently made the subject of scientific investigation, crystallography seldom is, and certainly never ranks among the popular sciences, probably because its pursuit requires a knowledge of geometry and trigonometry, and also owing to the meager knowledge of the crystalline forms assumed by mineral substances. It is the main stepping stone to researches in mineralogy, the study of which cannot be accomplished without a knowledge of crystallography.

Some crystals are very simple in form, and are remarkable for their symmetry, while in others the primary form is quite lost, becoming very complex, and may be bounded by more than a hundred different surfaces.

As is well known, hot solvents dissolve various salts in larger quantity than cold; it serves as one of the commonest methods of crystallizing solid substances. The more slowly a hot solution of the salt cools, the larger and more symmetrical are the crystals. A hot saturated solution is not the best for crystallizing, as some salts separate so rapidly as to nearly solidify to mass of minute crystals. Some, again, will not crystallize, even from hot saturated solution, if kept absolutely undisturbed; for example: Sulphate of soda will dissolve in half its weight of boiling water (the solution boils at 220°). If this solution is allowed to cool, an abundant crystallization will take place; but if the hot solution be put into a globular flask and corked tightly, it may be kept for several days without crystallizing, although moved from place to place. On withdrawing the cork, beautiful prismatic crystals will shoot through the liquid, until the flask is nearly filled with a solid mass of crystals; the whole becomes considerably elevated in temperature in consequence of the passage from the liquid to the solid form, while the rapid solution in water of salts abounding in water of crystallization is always attended by a diminution of temperature. The more water they contain the greater is their cooling effect during solution; as the contained water is solid, solution cannot take place without rendering latent a large amount of heat. To demonstrate this, if an ounce of sulphate of soda be mixed with an ounce of water, the temperature lowers in consequence of the solid hydrated salt becoming liquid; if an ounce of the dehydrated sulphate be employed, the temperature will rise on account of the water entering into combination, and the latent heat of the water is set free. Freezing mixtures may be made by causing the rapid liquefaction of the combined water of crystalline salts. A warm solution of the sulphate containing exactly two-thirds of its weight may be cooled without crystallizing, even in open vessels covered with glass plates; but a touch with a glass rod will start crystallization immediately. If, however, the rod has been recently heated, and not applied for even some time after, it will not cause crystallization.

Apparently, solid particles from the air falling upon the surface of the supersaturated solution form nuclei from which the crystals start; for if the flask containing the warm solution be provided with two tubes, and, after cooling, we blow through one, though the surface is considerably agitated it will not crystallize; but if we apply a pair of bellows, and blow through the same solution, crystallization will take place immediately, showing that unfiltered air contains microscopic particles which serve as points of attachment for the crystals. This may also be shown by making a solution of alum saturated at 194°. Close the mouth of the flask with a cotton plug and set aside for days or weeks, it will not crystallize; but carefully remove the plug and crystallization will commence from a few points immediately under the mouth of the flask.

It was formerly supposed that crystallization would not take place unless the substances had undergone fusion, solution, or sublimation, but it is now well known that the repeated vibration to which car wheels and axles are subject will cause them to crystallize; and iron when heated with carbon loses its fibrous and acquires a crystalline character, becoming steel, without fusion; under the trip-hammer wrought iron becomes crystalline and very brittle.

When crystals separate from a concentrated solution, they contain some of the mother liquor in their interstices, which is known as interstitial water (it is removed by draining and drying). Many crystals contain water chemically combined in a definite quantity; these are hydrated salts, and the combined water, the water of crystallization, so called because the crystalline form is lost if the water is expelled by heat, usually at 212°. What remains after heating to that degree is known as water of constitution. Let us take as example sulphate of copper: This beautiful blue salt contains one molecule of anhydrous sulphate combined with five molecules of water, and may be expressed $CuO.SO_3.5H_2O$. Exposed to the air the crystals remain unchanged, but if heated to 212° they become white and crumble to powder; this contains the molecule of sulphate of copper and one of water; the water of crystallization has disappeared, and the one molecule remaining, the water of constitution, may be expelled if the salt is heated to 390°.

Some crystalline salts do not contain water, and are known as anhydrous salts—as common salt.

In some cases the water of crystallization is emitted at ordinary temperatures, and the crystals assume a pulverulent condition, and are said to be effloresced. It is generally characteristic of soda salts, and is often observed with the sulphate or carbonate of soda. Sometimes, instead of losing water, they absorb it from the atmosphere, and become moist in consequence. They are then said to be deliquescent, as carbonate of potash or chloride of calcium.

Some bodies, as starch or glass, cannot be made to assume the crystalline state, and for that reason are called amorphous, that is, without form. Other substances, again, may present themselves in crystalline forms belonging to two different systems. They are then said to be dimorphous (two forms). This is the case with sulphur, which, when crystallized by fusion, yields oblique rhombic prisms (5th system), but is deposited from certain of its solutions in octahedra with rhombic base (4th system). The iodide of mercury presents a pecular instance of dimorphism. When crystallized from a saturated solution of iodide of potash it assumes the form of octahedra, and is of a rich scarlet color. When heated, it forms an amber-colored liquid, and sublimes in rhombic plates of a rich yellow color; upon standing, these become scarlet and break into octahedra with a square base (2d system). The scarlet powder may be crystallized on a card without fusion by simply heating over a spirit lamp. If, when cold, this yellow compound be rubbed with a piece of paper it is reconverted into the red iodide. These differently colored substances may be regarded as allotropic states. Dimorphous bodies may be regarded as exceptional to the general law of crystallization, yet they generally show some marked differences in hardness, specific gravity, luster solubility, fusibility, optical character, etc., thus showing some molecular difference.

When different substances possess a similar form they are said to be isomorphous. This is of very common occurrence. For instance, all chlorates, iodates, and bromates have the same crystalline form; so also do sulphates, selenates, chromates, and manganates, etc.

Common alum is a compound of sulphate of alumina and sulphate of potash; soda and ammonia being isomorphous with the potash, either may take its place without altering the form of the crystal; and as the oxides of iron, manganese, and chromium are isomorphous with alumina, either of them will replace it, and the crystalline form will be unaltered. Notwithstanding this isomorphism, the forms of crystals are generally characteristic of the substance. Quartz is known by its transparent six-sided prisms, fluorspar by its cubes, Iceland spar by its rhombs, salt by its cubes, alum by its octahedra, etc.

Solid substances obtained by fusion are usually a mass of crystals. This may be shown by melting sulphur, for instance; and when a pellicle has formed, puncture it in two places and pour out the remaining liquid; crystals will then be observed that would have otherwise passed unnoticed. So with ordinary tinware; if a mixture of one part of nitric and one of muriatic acids, with eight of water, be poured over the warm surface so as to remove the amorphous layer, the beautiful crystalline structure of the tin will be seen. It is then said to be moireed. Ice may be made to show its crystalline structure by soaking in water at about 32°; but it may be better seen on the window pane. The force with which cohesion is exerted in crystallization is very great, as may be exemplified by the freezing of water; the effect of this upon containing vessels, or on rocks, etc., is well known. Another property of crystals to be mentioned is that of splitting in certain directions when struck, corresponding to the planes of crystallization, and is termed cleavage, and indicates a regular form of structure. Thus, selenite (sulphate of lime) splits easily in two directions in one, so easily that it may be separated into the very thinnest sheets; these again breaking upon

pressure into rhombs. Iceland spar (carbonate of lime) may be cleaved in three directions so as to produce a rhomboidal crystal. Another curious fact observed by Mitscherlich is that some crystals expand in certain directions much more than in others; thus, in a rhomb of carbonate of lime, when heated from the freezing to the boiling point of water, the obtuse angles become more acute, and there is by measurement a difference of 8½' in the inclination of the planes of the crystal. It is probably owing to the inequality of the cohesive force in the two opposite directions. On cooling, it resumes its original shape.

The external forms of regularly crystalline solids are subject to great variation. The nature of the solvent, the temperature, the presence of other substances in the liquids, modify the form by creating new planes or angles. The crystals of alum lose their solid angles when an excess of acid is present, and they become converted into cubes when alumina is in excess. In foul and muddy liquids crystals usually deposit in their simplest form; in gelatinous or saccharine solutions they are usually single and remarkably sharp and regular. Salt deposits from a solution containing urea in octahedra instead of cubes, and sal ammoniac will form in cubes instead of octahedra, etc.

Crystallizable compounds will pass through parchment paper, while amorphous substances will not penetrate it. The former are called crystalloids and the latter colloids, and the process of separating them dialysis; as all crystalloids do not dialyze with equal rapidity, this serves as a means of separating salts from each other. Of course, when two or more salts are present in the same solution, if of different degrees of solubility and not isomorphous, they may be separated by crystallization. The salt that is the least soluble for the temperature is separated first.

In order to facilitate the study of crystalline forms they have been reduced to a few well marked systems. Before considering these, let us glance at the irregular forms. 1. Fibrous, spicular or acicular, as sublimed or lump chloride of ammonium. 2. Laminated or foliated, as mica. 3. Granular, as marble. 4. Plumose or feathery, as chloride of ammonium crystallized from solution. 5. Stellated, as snowflakes.

The regular forms are reduced to six systems, which are based upon their cleavage or to the geometric forms to which they are referable; besides these there are numerous allied forms.

The first system is the monometric (*i. e.*, one measure, alluding to the axes, which are all equal), cubic or regular. Imagine we have a cube of wood, and pierce it on all sides equidistant from the margin. Now, with a knife trim it off so that each pinhole will represent a corner. We have an eight-sided figure, an octahedron, which is an allied form of the first system. Now cut off each point again, so that all remaining surfaces are all of the same size and form, rhombic, *i. e.*, with the two opposite margins of each face parallel and presenting two acute and two obtuse angles; there being twelve faces, it is called a dodecahedron, and the faces being rhombs, rhombic dodecahedron; if it has twenty-four faces, and these have the form of a trapezium, it is called a trapezohedron; if it is bounded by four equilateral triangles, it is called a tetrahedron, and all being derived from the cube they are allied forms. The principal substances belonging to this system are copper, nickel, gold, lead, alum, salt, arsenious acid, diamond, iron pyrites, fluorspar, garnet, iodide and bromide of potassium, etc.

The second system, dimetric (*i. e.*, two measures, the axes being of two lengths). Take another block of wood half as long again as the piece just used, draw a line down all sides midway from the edges, and connect them across the top, and we have two of the principal axes. Now gird the block by another line, equal distances from each end; we have the second axis. So this system has three axes, two of which are of the same length and one shorter. Now let us cut this block as we did the cube, and we have another, but longer, eight-sided figure, a right square based octahedron, derived from the prism (block as it was at first). If the axes or planes of cleavage are from edge to edge, instead of from side to side, we have a second right square prism and a second right square based octahedron; the allied forms are pyramidal, quadratic, and square prismatic. The principal substances of this system are calomel, cyanide of mercury, ferrocyanide of potassium, binoxide of tin and zircon.

The third system, the trimetric, as defined, has three axes, all unequal; but the third system proper has four axes, three of which are equal in length, and is generally described as the rhomboidal system. In the rhomb the long axis extends from one corner to the most extreme one opposite. The other axes are equal, because they extend from side to side. To make the principal forms of this system, take a block, as before, but give it six equal sides, tetragons or rhombohedrons; this is the regular six-sided prism If now we cut this block to a point at both ends, preserving its six-sidedness, we have the bipyramidal or quartz dodecahedron. Take now and cut another block down to the thinness of one of the faces of the prism, the width of the prism being the length of the form; then by trimming away the edges so as to leave the sides in the form of rhombs till the width is only about three-fourths that of the length, this gives us the rhombohedron. If this be trimmed to a point at each end, and the faces being scalene triangles, we have a second dodecahedron, called scalenohedron.

To this system belong ice, nitrate of soda, arsenic, antimony, camphor, tourmaline, amethyst, graphite, etc.

The fourth system, to which the name trimetric belongs, has the axes precisely as the square prismatic, but no two are equal, owing to the rhombic shape of the crystal. Take another block, as in system 2, and with an awl bore a hole on the median line, equidistant from the ends and edges, right through the block, and two of the axes will be obtained; if one is bored through the center of the block from end to end, we have the other. Now remove from one face of the block about one-fourth its thickness; we have the rectangular prism. If instead of planing off the one-fourth from one of its faces we had removed some from each side diagonally opposed, so that the ends would be rhombs, and represent the axes by boring holes from corner to corner equidistant from the ends, and one through the center, as before stated, we should have the right rhombic prism. If the first be trimmed to a point at each end, thus forming two pyramids base to base, we have a right rectangular-based octahedron; if the second block be cut in like manner, we have the right rhombic-based octahedron.

This system is represented by bichromate of potash, Rochelle salt, citric acid, sulphates of magnesia, potash, zinc and baryta, nitrate of potash, etc.

The fifth system, monoclinic, that is, one of the axes reclining. This system has three axes, all of which may be unequal. Take two blocks just like the last, with this difference, the bottoms and tops or ends are to be cut off obliquely instead of square, so the block will lean over when set on end; the axes run just as they do in the fourth system, so bore the holes as before and the axes are represented. The one with the axes from side to side will be the oblique rectangular prism; if it be cut to a point at both ends as before, we have the oblique rectangular-based octahedron; the one with the axes from edge to edge will represent the oblique rhombic prism; this cut as in the preceding gives the oblique rhombic-based octahedron.

To this system belong sulphur (from fused), sulphate, carbonate, phosphate and borate of soda, sulphate of iron, chlorate of potash, sugar, sulphate of lime, etc.

According to Dana's system of crystallography, the diclinic is here introduced; it has two of the intersections between the three axes oblique.

The sixth system, or triclinic, as usually considered, contains three axes, which may be all unequal in length, and are all oblique to each other. They are doubly oblique, that is, they lean as the preceding, and laterally as well. Having cut two blocks as before, the right-angled one will represent the doubly oblique rectangular prism; and when cut to two points, as in the preceding cases, the doubly oblique rectangular octahedron. The block with rhomboid ends is a doubly oblique rhombic prism, and the octahedron from it is the doubly oblique rhombic octahedron.

To this system belong sulphate of copper and nitrite of bismuth, etc.

Sometimes a seventh system is considered, called the hexagonal; it really belongs to the third, and they are here treated together.—*Chicago Pharmacist.*

GLUTINE, A NEW PREPARATION FOR STIFFENING AND RENDERING GLOSSY CALICOES, WALL PAPER, ETC.

FRESHLY precipitated caseine is well washed, dried at 212°, and reduced to a moderately fine powder. This is levigated with a 50 per cent. solution of sodium tungstate. The mass becomes very thick as soon as the solution is added. It is now placed in a boiler and fully liquefied by heat. If it is too dry, a sufficient quantity of water is added. When it has acquired a completely homogeneous consistence, a little carbolic acid or salicylic acid is added to prevent its putrefaction. On cooling, the mass becomes nearly solid.

This preparation, which has by the inventor, Dr. G. H. E. Bering, been called glutine, when not completely hardened, is very soluble in water and very adhesive. It also adheres on metal, and may, therefore, be recommended for labeling tin cans, also bottles and jars. When entirely dry it resists for some time the action of water, but soluble in glycerine. A mucilage formed by a solution of glutine in water and a small proportion of glycerine forms an excellent flexible varnish for wall paper.

Dissolved in glycerine alone a tough clear mass is formed, which, spread on paper and passed through a solution of alum, acquires the firmness of good batter.

On account of the large quantity of wolframic acid contained in it, it may receive all different tints and colors by the addition of the decoctions of various dyewoods. If, for instance, cotton or linen soaked in a solution in glutine and dried, is passed through a decoction of logwood, it is dyed violet.

By soaking cottons or linens in glutine solutions, drying, and passing them through solutions of the mineral acids or salts of the same, they are dyed in various colors, resisting the action of soap and water and even that of alkalies.—*Chemiker Zeitung.*

SYNTHETICAL PRODUCTION OF RHODANIDES AND FERROCYANIDES.

THIS process, for which a German patent was recently issued to Messrs. Tscherniac and Guenzburg, is based upon the union of carbon bisulphide and ammonia. This is effected by exposing 100 parts of the sulphide, together with 200 parts of a 25 per cent. solution of ammonia, to a high pressure in a Papin wrought iron boiler. In from 3 to 4 hours rhodanide of ammonium and sulphureted hydrogen have been formed according to the formula $CS_2+2NH_3=H_2S+NCS,NH_4$. The ammonium rhodanide is now treated in a second vessel with lime. Hereby the ammonia is again liberated and may be collected for future use. From the calcium rhodanide obtained the rhodanides of other metals may be obtained by the addition of their carbonates, sulphates, or oxalates, by which the calcium is precipitated.

To convert the rhodanides into ferrocyanides, 6 equivalents of them are, together with 5 equ. of lime, 5 equ. of coal, and 1 equ. of finely divided iron, heated to dull redness. The mass is then lixiviated, the solution filtered, concentrated, and allowed to crystallize.—*Chemiker Zeitung.*

NOTE ON THE ACTION OF CHLORAL HYDRATE ON RHODANIDE OF AMMONIUM.

BY heating watery solutions of chloro-acetic acid with rhodanide of ammonium, Nencki obtained rhodaninic acid, $C_3H_3NS_2O$, which furnished beautiful colors with weak oxidizing agents. The latter circumstance prompted the author to study the behavior of chloral hydrate toward rhodanide of ammonium. A substance was obtained crystallizing in white silky needles, and having the formula $C_3H_3N_3Cl_4S$. It is insoluble in water, sparingly soluble in cold alcohol and ether, but readily soluble in hot alcohol. Diluted mineral acids and solutions of the alkalies do not affect it. Concentrated sulphuric acid dissolves it by the aid of gentle heat under decomposition, chloral escaping. The sulphur cannot be removed by metallic oxides, iodine, and similar agents. The formation may be expressed by the following equation: $[CCl_3.CH(OH)_2]_2 + (CNSNH_4)_2 = C_3H_3Cl_4N_3S + CNSH + 4H_2O$. The substance might be considered a molecular combination of sulphocyanic acid with two molecules of trichlorethylidenimide, which has so far not been isolated, and which appears to have the formula $(CCl_3CH{=}NH)_2$, CNSH. An alcoholic solution of it does not, however, give the characteristic rhodan reaction with perchloride of iron; this shows that it is not simply a sulphocyanate. —*Journal für Practische Chemie.*

A VARNISH FOR REPLACING TURPENTINE AND LINSEED OIL PAINTS.

FR. THIES, of Bissendorf, prepares a varnish consisting of 100 parts of colophonium, 20 parts of crystallized carbonate of sodium, and 50 parts of water, by heating these substances together and mixing them with a solution of 24 parts of strong liquor of ammonia in 250 parts of water. With the mass thus obtained the pigments are levigated without the addition of linseed oil or turpentine; the paint dries readily without the aid of a drier and looks very well, especially when varnished. The paint keeps well even under water and becomes very hard. The cost is said to amount to about one-third of that of ordinary oil paints—*Deutsche Gewerbe Zeitung.*

PROCESS FOR PREPARING SULPHATE OF BARYTA FOR PAINTING.

PURE amorphous sulphate of baryta may be used as a water color, but not as an oil paint. The sulphate gained by precipitation by sulphuric acid of the chloride or some other soluble baryta salt, called "blanc fixe," forms, mixed with linseed oil, a glassy, granular mass. The precipitate obtained by a solution of a sulphate behaves similarly, although in an inferior degree. Meissner proposes to dry the precipitate obtained by means of a sulphate, and heating the same as soon as possible after precipitation to a red heat in a muffle. The mass is, while yet glowing, thrown into water. By this sudden change of temperature the sulphate of baryta is altered to a considerable degree. After being dried, ground, and levigated with a small quantity of linseed oil, it mixes readily with the required proportion of the latter, and forms a white paint equal in all respects to white lead. If the paint shall merely serve as a body for different shades of other colors, the latter must be added to the water.—*Deutsche Gewerbe Zeitung.*

IMPROVEMENT IN THE MANUFACTURE OF METHYLANILINE.

MESSRS. SCHUETZENBERGER & VINCENT presented to the Société pour l'Encouragement de l'Industrie Nationale, at Paris, the following report on a recent improvement in the process for manufacturing methylaniline:

This substance is generally produced by the action of the iodide and bromide of methyl on aniline. The high price of iodine and bromine long ago induced chemists to experiment, with a view of discovering a new and less expensive process, especially after Mr. Chas. Lauth had succeeded in producing a magnificent violet by the direct oxidation of methylaniline by means of the salts of copper.

The next improvement made was that introduced by Mr. Bardy, who, profiting from the action of chloride of ammonium on alcohols at high temperature and high pressure, discovered by Berthelot, heated, under similar conditions, chlorhydrate of aniline with methylic alcohol, and obtained in this manner methylanilinic chloride.

Hereby the manufacture on a large scale of methylaniline violet was rendered possible.

In establishments of this kind this process is conducted in enameled vessels under very high temperature and a pressure of about twenty atmospheres. The vessels are under these conditions rendered unfit for use within a very short time, and the high pressure limits their capacity considerably. Besides, there are, at the high temperature necessary, compounds of a higher degree of oxidation formed, which not only reduce the quantity of methylaniline obtained, but also injure its purity. The disadvantage connected with the latter circumstance is considerable, inasmuch as a brilliant violet can only be produced from pure methylaniline.

These disadvantages are entirely overcome by the improvement introduced by Messrs. Schuetzenberger & Vincent, consisting in the employment of liquid sub-chloride of methyl.

The latter substance is obtained pyrogenetically by the decomposition of chlorhydrate of trimethylamine. After being obtained in its crude state, it is purified by successive washings with muriatic acid, water, sulphuric acid, caustic soda solution, and distilled water. It is then dried by being passed over chloride of calcium and liquefied by pressure and refrigeration. The pure, anhydrous sub-chloride is kept and transported in strong steel flasks.

The apparatus employed by Messrs. Schuetzenberger & Vincent for methylating aniline is composed of an unenameled stout brass boiler, provided at its upper portion with a safety valve and a manometer. It contains an agitator, the shaft of which passes through the upper portion of the boiler, and operated by means of a bell and pulley.

On a platform above the boiler is placed a cylindrical vessel, receiving the liquid sub-chloride of methyl. Its upper portion is connected with that of the boiler by a copper tube, by which the equilibrium of pressure is established between the two receptacles. A second tube leads from the bottom of the upper cylinder to the boiler, and serves to conduct the sub-chloride into the latter. Both tubes are provided with stop-cocks. The upper portion of the cylinder receiving the sub-chloride is connected by a tube with a worm and receiver, which may be constantly cooled. From the receiver a siphon leads to the boiler. The latter is charged through an opening, which may be closed by a screw cover, and is placed in a closed kettle, through which steam or cold water may be passed, as necessity calls for.

The charge consists of 90 lbs. of aniline for every 62·5 gallons capacity of the boiler, mixed with a quantity of milk of lime, containing sufficient alkali for neutralizing all the chlorine of the sub-chloride used. The boiler being closed, the surrounding kettle is filled with salt water, which is heated by steam to the boiling point. At this temperature it is kept for one hour. Meanwhile the mixture contained in the boiler has been kept in constant motion by the agitator, and attained a temperature of 212°.

The admission of steam and the operation of the agitator are now interrupted, and the salt water is drawn off.

The sub-chloride of methyl is cautiously admitted into the boiler, and the reaction sets in immediately. The pressure rises considerably, and should not be allowed to exceed 18 lbs. For this purpose, it will be sufficient to introduce about a pound of the sub-chloride per minute for a boiler of the above-mentioned size.

Pending the reaction of the substances on each other, the temperature within the boiler rises considerably, and a certain quantity of the product evaporates and distills over into the receiver, from which it is returned to the boiler again through the siphon.

As soon as all the sub-chloride has been drawn from the cylinder, the stop-cocks are closed, and steam is again applied to the boiler, to finish the process. The pressure diminishes gradually, and as soon as only 6 lbs. of pressure are indicated by the manometer the operation is interrupted. The boiler and its contents are cooled down rapidly by conducting cold water around the same. As soon as cold, the boiler is emptied, and the dimethylaniline formed may be easily separated from the solution of chloride of calcium.

The process takes up about four hours. On account of the relatively low pressure and temperature employed, the product is very pure, and the quantity obtained from a given amount of aniline falls never below 116 parts for every 100 parts of aniline employed—much more than obtainable in any other way. The dimethylaniline thus obtained distills at a temperature of 345° F.

This process is now employed at the chemical works of the Messrs. Brigonnel & Son, St. Denis, five large boilers being in nearly constant operation, and it is about to be introduced into several manufactories in foreign countries.—*Comptes Rendus de la Société pour l'Encouragement de l'Industrie Nationale.*

PROCESS FOR RECOVERING THE ARSENIC CONTAINED IN THE RESIDUES FROM FUCHSINE MANUFACTURE.

MOST of the arsenic used in the manufacture of fuchsine is found in the solid and liquid residues. The former consist chiefly of resinous matter, mixed with arseniates and arsenates of lime, more or less soluble in water; the liquid residues are composed of solutions of arseniate, arsenate, and chloride of sodium. The solid residue serves as fuel for concentrating the liquid ones, and for roasting and subliming the salts obtained. The vapors of arsenic are, together with these, formed by the combustion of the solid residue conducted into ordinary condensing chambers, where the arsenious acid is deposited, while the other products of combustion escape. The residue consists chiefly of arsenate and chloride of sodium, which may be used again in producing fuchsine. This process forms the subject of a patent, granted recently to Mr. Leonhard, of Mainkow.

PURIFYING OIL OF COGNAC.

THE beautiful green color so often met with in the oil of cognac, imported from Europe, is generally derived from an appreciable quantity of copper, which, of course, must render the liquor made from it highly injurious. To purify the oil heat it to about 114° F., and shake with one-tenth of its volume or a saturated solution of tartaric acid. Set aside for ½ hour and filter.

PROCESS FOR MANUFACTURING SODA AND POTASH FROM THE SULPHIDES.

SIEEMANN mixes the sulphide of soda and potash, finely powdered, with a quantity of alumina sufficient for the formation of an aluminate. The mixture is heated in an iron retort to bright redness. Sulphurous acid is generated and conducted to an ordinary leaden sulphuric acid chamber. The fused mass remaining consists of aluminate and a small quantity of oxysalts of sulphur, besides some undecomposed sulphide. It is lixiviated, and a current of carbonic acid is passed through the resulting solution. For this purpose the gases coming from the furnace may be utilized. Alumina is precipitated and may be used over again, and a solution of carbonate of the alkali used is formed, which only needs purification from a small quantity of sulphate.—*Chemiker Zeitung.*

SPONGY IRON AND ANIMAL CHARCOAL AS MATERIALS FOR PURIFYING WATER.—By L. LEWIN (*Zeitschr. f. Biologie*).—The greater part of this paper is devoted to an account of experiments on the action of Bischoff's spongy iron filter upon impure water. It is shown that if urine, whether dilute or concentrated, be passed through one of these filters, and if the filter be then washed several times with pure water, the whole or almost the whole of the solid matter, as also of the nitrogen, originally present in the urine, is obtained in the liquid that has passed through the filter. About one-fourth of the total nitrogen of the urine is found in the filtered urine; the first quantity of wash-water generally contains rather more than a second fourth, and the successive quantities of water contain less and less nitrogen.

Nor is the carbon of organic bodies retained by spongy iron. Almost the whole of the sugar and sodium chloride contained in a quantity of milk serum which was passed through the filter, was proved to be present in the filtered liquid after successive washings with pure water.

Bacteria were also found abundantly in filtered urine which was known to contain these organisms before filtration.

Lead was removed by this filter from a slightly acid solution, but only partially from an alkaline solution; the filtered liquid from which lead had been removed contained considerable quantities of iron.

The author regards the spongy iron filter as merely capable of removing suspended matters, and certainly as not more satisfactory in its purifying action than a common filter of sand.

NEW DYES.

THE Messrs. Meister, Lucius & Brüning have been for some time past producing, at their extensive chemical works in Hoechst-on-the-Main a series of dyes apparently destined to replace annatto, archil, and cochineal, in dyeing wool and silk, as well as in printing on calicoes.

The process employed is described in the *Chemiker Zeitung* as follows:

The first step consists of the production of naphthole disulphuric acid from betanaphthole, which is afterwards permitted to act on aniline, toluidine, hylidine, and naphthylamine, or diazo compounds derived from them.

Twenty pounds of betanaphthole are kept for twelve hours at a heat of 230° F., having previously been mixed with sixty pounds of commercial sulphuric acid. Hereby two modifications of naphthole disulphuric acid are formed, differing chiefly by the degree of solubility of their respective salts.

The solution obtained is saturated by carbonate of sodium and evaporated to dryness. The residue, consisting of a mixture of a naphthole disulphate, soluble in alcohol, and one insoluble in that menstruum, is treated by alcohol of 80° Tralles. The insoluble salt, termed "Salt R," is collected on a filter and dried, while the soluble salt, "Salt G," is obtained from the solution by evaporation to dryness.

Red colors are produced from the salt R, yellow ones from salt G. For producing, for instance, a beautiful bright red, thirteen pounds of xylidine are dissolved in twenty-four pounds of muriatic acid of 20° Baumé, previously diluted with two hundred pounds of water. To the solution are gradually added, while the apparatus is constantly cooled, nine pounds of nitrate of potassium. A solution of dioxylole chloride is the result, to which are now added four hundred pounds of water, containing in solution forty pounds of 10 per cent. liq. ammonia. The dye is now precipitated in form of a bright red paste, which is collected, dried, and powdered.

By substituting the salt 'G' for the salt 'R,' orange or yellow precipitates are obtained. The various shades of both dyes may be obtained by employing the different substances above-named, or their diazo compounds.

PRINTING ON GLASS.

Mr. V. KOEPPE has obtained a patent for the German Empire for the following mode of printing on glass, china, etc.:

The first step is to obtain a positive plate consisting of plaster Paris, type metal, cement, raoline, etc., from a woodcut or electrotype. From the positive plate thus formed a negative is obtained, the preparation of which is described as follows: 50 parts of good glue are soaked in 40 parts of water. Then 50 parts of glycerine are added, and the mixture exposed to a gentle heat until the glue is completely dissolved. Then one part of olive oil is added, the mixture again heated to the boiling point, and now the plate may be cast. On cooling, the substance retains the shape imparted to it by the negative, but remains very flexible. It may be readily attached to wooden plates or cylinders, and is now ready for printing. Single letters may be cast as well as entire plates, but the slender stem must be incased in a hollow metal prism. Such type may be composed and used precisely as ordinary metal types.

The colors are applied to the plates by means of rollers. The printing inks are composed of the pigment of the desired shade, levigated with sufficient balsam of copaiba to form a paste of buttery consistence, to which 10 per cent. of Venice turpentine and 50 per cent. of semi-resinified oil of turpentine or lavender are added. Are any portions of the printed surface to be gilded or bronzed, the powdered gold or bronze is to be applied to the respective parts immediately on being printed. The printed piece is now ready for the oven.—*Gewerbe Zeitung.*

ENORMOUS GROWTH OF ROOTS OF THE LUPINE.—Upon a sandy knoll in the town of Chicopee, Mass., just north of the Chicopee River, the lupine (*Lupinus perennis*, L.), grows in great abundance. Besides the lupine a scanty vegetation only is found, consisting of scattering tufts of grass and occasional blackberry vines. Having charge of some excavations in this mound, I was surprised at the enormous growth to which the rootstocks of the lupines had attained; the excavations (which were made for a reservoir), were from 12 to 15 feet in depth; the roots extended from the surface through this entire depth, and penetrated to an unknown distance below, probably to the water table, which must have been at least 10 feet beneath the bottom of the excavation. The roots were exceedingly woody, and immediately below the surface were full 3 inches in diameter. The roots of the plants which were growing upon the higher portion of the knoll were fully 25 feet in length, an enormous development with the ascending axis of the plant, which rarely exceeds 2 feet in height. The extraordinary growth must be accounted for by the absence of moisture in the sand, the roots passing down to strata which furnish the necessary moisture for the plant.—ARTHUR F. GRAY, Davenport, Mass.

This property of the lupine—of penetrating deeply in search of moisture—has been made available by European agriculturists, especially in Germany, for the improvement of sandy soils. The lupine is merely topped with the scythe the first year, when thus employed. By the second or third year the plants become strong enough to afford excellent pasturage, and are very fattening to sheep. The stalks, also, if macerated in hot water, yield a pith of exceedingly nutritious quality, and when sheep are fed upon this material, their fleece is greatly increased. Eventually the lupines are turned under by the plow, and the soil is found to be sufficiently enriched to bear other crops. An experiment of this sort was tried with great success some years ago near Sherbrook, Canada, and a sandy waste was thus converted into a fertile field.—ED. *Science News.*

REVIEWING the Report of the British Coal Mine Commission, *Nature* remarks that the dangers due to the use of explosives in mines are of three kinds: first, the shot may ignite an accumulation of gas directly; second, it may effect the same thing indirectly by driving the flame of a safety-lamp burning in the accumulation through the meshes of its wire gauze cylinder; third, the sudden rush of flame and the violent disturbance of the air caused by a blown-out shot (that is to say, one which expels its tamping without bringing down or even breaking the rock) may raise and ignite the coal-dust in front of it, and more especially if it is directed towards or parallel with and near to the floor. In the last case the flame has been often known to extend to a distance of thirty, forty, and even eighty yards from its origin, and such a disturbance taking place under favorable conditions is quite sufficient to initiate explosions such as those of Blantyre, Haydock, Abercarne, and Dinas, in which close upon a thousand lives have been lost within the last eighteen months. When we add that each of these mines was very dry and contained plenty of coal-dust, and was not known to contain more than insignificant accumulations of fire-damp, quite insufficient to account for a tithe of the extent and violence of the explosions, we have said enough, we think, to make it apparent how pressing is this matter.

Blasting operations can be safely carried out in any mine if the shots are not fired near explosive accumulations, if the lamps are of such a construction that they cannot burn in an explosive atmosphere, and if the mine is a damp one. It is easy enough to provide the two first requirements, and it is obvious that by plentifully watering the roadways we can turn a naturally dry mine into a damp one and avoid danger such as we have described from blasting, as well as localize explosions of fire-damp.

PAINLESS DEATH.

IN one of his lectures Prof. Tyndall spoke of the probabilities in favor of the entire absence of pain accompanying death by lightning. It is popularly supposed that an impression made upon the nerves—a blow or puncture—is felt at the precise instant it is inflicted; but such is not the fact. The seat of sensation is the brain, and intelligence of the injury must be transmitted to this organ through a certain set of nerves, acting as telegraph wires, before we become conscious of pain. This transmission or telegraphing from the seat of injury to the brain requires time, longer or shorter, according to the distance of the injured part from the brain, and according to the susceptibility of the particular nervous system operated upon.

Helmholtz, by experiments, determined the velocity of this nervous transmission in the frog to be a little over 85 feet per second; in the whale, about 100 feet per second; and in man, at an average of 200 feet per second. If, for instance, a whale 50 feet long were wounded in the tail, it would not be conscious of the injury till half a second after the wound had been inflicted. But this is not the only ingredient in the delay. It is believed that to every act of consciousness belongs a determinate molecular arrangement of the brain, so that, besides the interval of transmission, a still further time is necessary for the brain to put itself in order for its molecules to take up the motions or positions necessary to the completion of consciousness. Helmholtz considers that one-tenth of a second is required for this purpose. Thus, in the case of the whale, there is, first, half a second consumed in the transmission of the intelligence through the sensor nerves to the brain, about one-tenth of a second consumed by the brain in completing the arrangement necessary to consciousness, and, if the velocity of transmission from the brain to the motor nerves be the same as that through the sensor, about half a second more is consumed in sending the message to the tail to defend itself. Therefore one second and one-tenth would elapse before an impression made upon its caudal nerves could be responded to by a whale 50 feet long.

If we regard as correct the calculations representing the average velocity of transmission in the human nerves, and if we estimate the distance from the origin of the filaments in the brain to their termination in the foot as 5 feet, the time required, in case some one steps on your favorite corn, for the news to be telegraphed to the brain, for the brain to prepare a message and to telegraph the same to the muscles of the leg to draw the foot away, would be about one-twentieth of a second. Now, it is quite conceivable that an injury might be inflicted which would render the nerves unfit to be conductors of sensation, and if this occurred, no matter how severe the injury might be, there would be no consciousness of it. Or it might happen that the power of the brain to complete the molecular arrangement necessary to consciousness would be wholly suspended before there would be time for the transmission of the intelligence of the injury. In such a case, also, although the injury might be of a nature to cause death, this would occur without feeling of any kind. Death in this case would be simply the sudden negation of life, without any intervention of consciousness whatever.

Doubtless there are many kinds of death of this character: the passage of a rifle bullet through the brain is a case in point. The time required for the bullet in full velocity to pass clean through a man's head may be roughly estimated at a thousandth part of a second. Here, therefore, would be no room for sensation, and death would be painless. But there is another action which far transcends in rapidity that of the rifle ball. A flash of lightning cleaves a cloud, appearing and disappearing in less than a hundred-thousandth part of a second, and the velocity of electricity is such as would carry it in a single second of time over a distance almost equal to that which separates the earth and moon.

A luminous impression once made upon the retina endures for about one-sixth of a second, and this is why we see a ribbon of light when a glowing coal is caused to pass rapidly through the air. A body illuminated by an instantaneous flash continues to be seen for the sixth of a second after the flash has become extinct; and if the body thus illuminated be in motion, it appears at rest at the place where the flash falls upon it.

The color-top is familiar to most of us. By this instrument a disk with differently colored sectors is caused to rotate rapidly; the colors blend together, and, if they are chosen in the proper proportions, the disk will appear white when the motion is sufficiently rapid. Such a top rotating in a dark room and illuminated by an electric spark appears motionless, each distinct color being clearly seen. Prof. Dove has found that an illumination by a flash of lightning produces the same effect. During a thunderstorm he put a color-top in exceedingly rapid motion, and found that every flash revealed the top as a motionless object with its colors distinct. If illuminated solely by a flash of lightning, the motion of all bodies on the earth's surface would, according to Prof. Dove, appear suspended. A cannon ball, for example, would appear to have its flight arrested, and would seem to hang motionless in space as long as the luminous impression which revealed the ball remained upon the eye. If, then, a rifle bullet passing through the brain, move with sufficient rapidity to destroy life without the interposition of sensation, much more is a flash of lightning competent to produce this effect. We have well authenticated cases of people being struck by lightning who, on recovery, had no recollection of pain.

The Rev. Dr. Bartol, who was lately nearly killed by lightning, expressed the belief that if the stroke proved fatal, it must produce the most agreeable mode of death; but to be stunned, as he was, is very unpleasant. As soon as consciousness returned he experienced a terrible sense of oppression, and an irresistible weight seemed passing through him, while his mind was dazed so that for a while it seemed he had suddenly been precipitated into wonderland. His recovery was attended by headache, continued for a week.

The following case is described by Hemmer: On June 30, 1788, a soldier in the neighborhood of Mannheim, being overtaken by rain, stationed himself under a tree beneath which a woman had previously taken shelter. He looked upward to see whether the branches were thick enough to shed the rain, and in doing so was struck by lightning, and fell senseless to the earth. The woman at his side experienced the shock in her foot, but was not struck down. Some hours afterward the man recovered, but remembered nothing about what had occurred, save the fact of his looking up at the branches. This was his last act of consciousness, and he passed into the unconscious condition without pain. The visible marks of a lightning stroke are usually insignificant, the hair being sometimes burnt, slight wounds occasioned, or a red streak marking the track of the electric discharge over the skin.

Prof. Tyndall relates—standing in the presence of an audience, about to lecture—that he accidentally touched a wire leading from a charged battery of fifteen large Leyden jars, and the current passed through his body. He says life was absolutely blotted out for a very sensible interval, without a trace of pain. In another second or so consciousness returned. He saw himself in the presence of the audience and in contact with the apparatus, and immediately realized that he had received the battery discharge. The intellectual consciousness of his position was restored with exceeding rapidity, but not so the optical consciousness. To prevent the audience being alarmed he stated that it had often been his desire to receive, accidentally, such a shock, and that his wish had at length been gratified. But while making this explanation the appearance which his body presented to himself was that of being in separate pieces. His arms, for example, seemed to be detached from his body and suspended in the air. Memory and the power of reasoning and speech were complete long before the optic nerve recovered from the electric shock.—*National Medical Review.*

CLINICAL LECTURE ON BURNS.

By R. J. LEVIS, M.D., Surgeon to the Pennsylvania Hospital and to the Jefferson College Hospital.
Delivered at the Pennsylvania Hospital.

No injuries of ordinary occurrence produce such great and prolonged suffering as burns. Unfortunately, they are rapidly increasing in frequency and severity, due to the use of heat in mechanical occupations, to the universal presence of friction-matches, and, most seriously, to the extended application of highly-inflammable and even explosive fluids for the purpose of illumination. Petroleum is answerable for a great number of the most dreadful of these injuries that we admit to the wards, and the ignorant or careless use of it in attempting to kindle fires, or in filling lamps whilst the wick is still burning, causes some of the greatest human misery and frequent death.

Probably our hospital experience would show that no class of injuries, in proportion to the number, is so fatal. The majority of burns are of domestic occurrence, and women and children the most frequent sufferers. Our records give evidence of the great mortality of cases of burns among children, and of the termination of the sufferings of many, dying within a short period after their admission to the wards, without reaction from the primary shock of injury.

You have seen already, during this clinical term, how varied may be the character of injuries from the application of either dry or moist heat, from a mere erythematous redness of the skin produced by a momentary flash of burning gas or escaping steam to the total disorganization and destruction of a part. Burns vary in severity according to their extent of surface as well as to destructive depth. The complete incineration of a part, as a hand or a foot, might be a matter of less gravity than even a merely diffuse erythema affecting a large area of the skin. A man once walked into this hospital who had fallen into a vat or tank, and was immersed in water not hot enough to produce more than a superficial irritation of the derma, and without in any place blistering, yet he died within a very few hours. I have had cases in which part of a limb has been totally charred, through integuments, muscles, and even bone. One was that of a man who had been held for some time in the ruins of a fallen blast-furnace, while portions of his feet and hands were immersed in flowing molten metal until even the bones were charred; yet he recovered—of course in a maimed condition. In another instance a man's leg was, by a curious accident, so held in a pot of molten iron that he could not extricate it, and the disorganization was total. So it is evident to you how the grades of such injury must vary.

Arbitrary classifications of burns are made by some surgical authorities, based on their depth, but you need not be troubled about memorizing six or eight distinctions if you will merely bear in mind that the pathological significance, the prognosis, and the treatment of the injury will vary with its locality, the extent of surface involved, and the depth of penetration. If the application of heat be only momentary, a mere erythematous redness will follow, the cuticle will soon desquamate, and then complete restoration will ensue. A more prolonged application of heat will produce serous effusion, elevating the cuticle in the familiar blisters or bullæ. A deeper burn disorganizes the entire skin so that effusion cannot take place; and I have spoken of still deeper destruction, even to the complete incineration, of a part.

A scald results from the application of moist heat, which, with water or steam, is not usually above a temperature of 212°, and the action is liable to be but momentary and superficial in effect. But the prolonged impression of moist heat may be as destructive—and in a pathological view the effect is the same—as that of dry heat, and I am inclined to use the word burn in a generic sense, to include the general action of heat, moist or dry, on the body.

Some of the cases of deeply destructive burning of parts I have seen among persons who were insensible at the time of receiving the injury, as in cases of epileptics who have fallen into open fires or against stoves, and the coma of drunkenness has frequently caused the same. One of the most extensive and deep burns I have ever seen in these wards was in the case of a man who was at the time intoxicated by the fumes of a lime-kiln by which he had lain to warm himself until his back was deeply roasted from the nape to the coccyx.

It is one of the curious traditions of surgery that the effect of exposure of the surface of the body to the rays of the sun, producing erythema of the skin, is in the text books classed with burns. That effect is rather due to the intensity of solar light than to heat. I have seen the so-called sunburn produced when the air was cold and the parts exposed necessarily colder than those which remained covered by clothing; and in the case of a boy whose neck and back were extremely vesicated from exposure to the sun whilst bathing, the skin had been continually wet with cold water, and actual burning was impossible.

When a severely burned patient is first brought into the wards, our attention is at once directed to two important and urgent demands of treatment—the great pain that he is suffering, and the shock of injury. The immediate inhalation of an anæsthetic and a hypodermic injection of morphia are the speedy recourse, and these should be followed, if pain continues, by the internal administration of morphia, decisively, but yet with caution. When the injury is very severe and the prostration extreme, the patient is sure soon to have well-marked rigors, with tremor, and the sensation of heat yields to a distressing chilliness. In the severest cases coma comes mercifully, and continues until death relieves the sufferer. When there is evidence of great general shock, it must be treated, as in ordinary traumatic injuries, by stimulants, quinine, nutrients, and warmth. If the clinical thermometer, placed beneath the tongue, indicates a temperature below the normal, it may not be enough to wrap the patient in blankets, which merely retard the escape of heat from the body, but warmth must be artificially imparted by contact with cans of hot water placed beneath the coverings.

The removal of the clothes of a badly-burned patient should be effected with the greatest care, cutting them off and removing them in portions, so as to avoid detaching the adherent cuticle. When blisters or bullæ exist, they should be merely punctured with the point of a needle, so as gradually to drain away the serum, always leaving the epidermis as the natural and unirritating protection for the burned surface.

After the first considerations of relieving pain and shock to the system, the local treatment of burned surfaces will require attention, and this must vary with the portion of the body injured, and also with the superficial extent and depth. Patients are always distressed by the desiccating influence of the air on even slightly-burned parts, and protection by dressings with lotions or unguents is essential. We are, in these wards, in the habit of applying, at first, mildly-astringent and antiseptic unguents for this purpose, such as the benzoated ointment of the oxide of zinc, or the carbolized ointment of the oxide, in the proportion of one part of carbolic acid to sixteen or twenty of the ointment. Such applications are soothing and disinfectant; and, if the surface is extensively blistered, with the epidermis broken, the comfort of the patient will be much increased by incasing the part in a layer of carded cotton, frequent disturbance of the dressing being carefully avoided.

In cases of extensive burn of the surface of the trunk and extremities, involving a very large area of skin, and where changes of the dressing would cause much suffering, I have directed that almost the entire body be simply wrapped in a linen sheet saturated with a slightly carbolized oil. For this purpose linseed oil, from its viscid character, is probably the best. Most of the domestic remedies which are resorted to have some merit in at least protecting the parts from the air, but such popular applications as flour, molasses, starch, soap, and glue have the inconvenience of being dirty, and some of them incline to form crusty masses over the surface which are not easily removable. The familiar combination of linseed oil and lime-water—a soapy emulsion—has no real merit, and has the disadvantage of becoming disgustingly offensive when combined with the discharges from burned surfaces. It is at all times exceedingly difficult to prevent fetid effluvia from the bodies of patients who are extensively burned; and such are the most offensive surgical cases we ever have in the wards. As ablutions and frequent changes of dressings are attended with suffering, the prevention of putridity is best effected by the use of carbolic acid, which has the property of being a local anæsthetic as well as an antiseptic.

The application of a paint of carbonate of lead and linseed oil, as practiced by Professor Gross, is said to be very soothing, quickly relieving pain, and it has the merit of being readily attainable in places where severe burns are apt to occur. The originator of this treatment says that he has never seen evidence of its being followed by the specific toxical effects of lead, even where the dressing is extensively applied; but in individuals who are peculiarly susceptible to saturnine influence it might be dangerous. A recently-proposed remedy, which has remarkable virtues claimed for it, is the bicarbonate of sodium, in fine powder, dusted over the burned surface or applied as a saturated aqueous solution. It is said to relieve pain instantly, and that burns heal readily under the application. The watery solution of bicarbonate of sodium would have the serious objection of other wet dressings—in chilling the patient, when largely used—and it must be remembered that during the existence of shock from burns the temperature is often much below the normal, and that the restoration and maintenance of warmth should be a primary object. Dr. Ludlow, of this city, states that the application of the ordinary brown resin soap, spread on linen cloths, quickly relieves pain, and is a very satisfactory dressing.

When mortification of a part occurs from a deeply-penetrating burn it must be treated, as gangrene from other traumatic causes, with cataplasms and antiseptics, to facilitate separation of the dead from the living tissues, and to avoid fetor and septic infection of the patient's system.

There are some remarkable visceral complications of burns which you should watchfully and carefully anticipate, and, if possible, guard against. The statistics of death from burns show that associated intra-thoracic, intra-abdominal, and cerebral lesions are the causes of death in nearly one-half of the fatal cases. These affections are usually either congestion or inflammation, and are ordinarily associated with burns of the overlying integument. Generally tonic and stimulating treatment seems to be the most available in such complications.

There are other serious pathological associations of burns, to which I can at this moment make but passing reference. Intestinal ulceration is a frequent and curious attendant of extensive burns, particularly of the trunk, and causes many fatal terminations. This remarkable associated lesion, which affects the mucous membrane of the small intestines, particularly the duodenum, is not well explained, and cannot always be diagnosticated, but the persistence of uncontrollable diarrhea and vomiting should incline you to direct your attention to the probability of the existence of such lesion.

There are some structural changes resulting from burns involving destruction of integument, which result in cicatricial contraction, and often require the aid of reparative or plastic surgery for their relief. The contact of denuded surfaces is liable to result in their unnatural union: so they should, by positions and by dressings, be kept apart, and in parts liable to be deformed by contraction the healing integument should be kept stretched until long after cicatrization is completed.—*Medical Times.*

REMOVAL OF HAIR BY ELECTRICITY.*

By GEORGE HENRY FOX, M.D., New York.

NEXT to our sympathy with the man who cannot raise a beard, comes our pity for the woman upon whom nature has unkindly bestowed one. Her distress need not be pictured, as there is scarcely a physician present who cannot call to mind some lady who has besought him for a remedy to rid her of hair upon the face. What has been done in such a case? Possibly the various depilatories recommended in text-books on dermatology have been tried and found to be no more serviceable and far more unpleasant than the use of a razor. Possibly an effort has been made to destroy the hairs by inserting hot needles, or injecting acid into the follicles. These means having proved futile, or, perhaps, harmful, it is possible that a vain attempt has been made to persuade the sufferer that the matter was of little or no consequence, and that cutting the hairs short, or plucking them with tweezers would remedy the evil.

It is quite probable, however, that the statement has been made that nothing could be done; and the patient, convinced that something must be done, has finally fallen into the hands of some advertising charlatan, and only yielded to despair after having been thoroughly swindled.

This form of perverted capillary nutrition, which shows itself upon the female face in the form of a promising moustache or beard, is by no means rare. Physicians are not only called upon to treat this, but also the few stiff hairs which are so often seen growing from a small fibrous tumor or pigmented nævus. In both these cases it is evident that destruction of the hair papillæ is the only means of radical cure; and in electrolysis we have, I am convinced, the best, if not the only practicable means of accomplishing this end.

* Paper read before the Medical Society of the State of New York, February 4, 1879.

To ophthalmology is due the credit of first applying electricity for the purpose of destroying hairs. Dr. Michel, of St. Louis (Clinical Record, Oct. 1875), recommended electrolysis in the treatment of trichiasis, and employed a method very similar to that which I have found serviceable. Dr. Piffard (Diseases of the Skin) speaks of treating two cases of hairy nævus by electrolysis, and in a paper presented to the American Dermatological Society (Aug. 1878), on the treatment of hirsuties, Dr. Hardaway advocated its use. As far as my knowledge goes, this is the extent of the literature of the subject.

The apparatus required for the operation is an ordinary galvanic battery, with a needle of fine wire attached to the negative electrode, and a sponge-tipped positive electrode, which should be applied to the skin as near as convenient to the field of operation. In my first attempts I introduced into the follicle a fine cambric needle, wound to within a quarter of an inch of the point, with a copper wire which joined it to the negative cord of the battery. This simple contrivance will answer the purpose, although a better substitute I have found in a fine flexible steel needle, used by dentists in extracting nerves. This needle, together with a convenient handle or holder, can be obtained from any dental instrument dealer, and is readily attached to the battery cord.

In many cases where the hair follicles are large, as they are apt to be upon the cheeks, a fine platinum wire is superior to any form of needle. It can be filed to a point by means of a jeweler's file, and by virtue of its flexibility it will reach the bottom of the follicle (the hair having been previously extracted), while a stiff and sharp needle would pierce the follicular wall and fail to reach the hair papilla. In fact, whenever a needle is employed, the direction of the hair must be carefully noted or the needle will certainly go wide of its mark and fail to accomplish the destruction of the hair. On the other hand, a fine, soft, flexible wire will follow the course of the follicle in some instances, as a soft rubber catheter follows the curve of the urethra in its introduction into the bladder. Where, however, the follicles are naturally small, as about the neck, no matter how coarse the hairs may be, the soft wire will either bend upon itself, or pierce the wall of the follicle and go in a wrong direction. In such a case it is better to use the stiff needle and introduce it in the direction of the supposed site of the papilla.

In operating, a strong light is essential to success. The patient should sit by a large window and preferably in the sunlight. Where the hairs are numerous and the follicles small, the eyes of the operator soon tire, and a séance of more than a half or three-quarters of an hour is apt to become both unpleasant and unprofitable. The use of a lens has been recommended, but as both hands are generally employed in the operation, I cannot see how it could be conveniently used unless fitted to the eye.

The extraction of the hair should precede the introduction of the needle or wire, in all cases where the follicle is of large size. In case of fine hairs, however, it is unadvisable. Often when a fine hair is extracted it is not an easy matter to see the mouth of the follicle. If the light is at all dull or the eye fatigued, the follicle from which the hair has been extracted is lost, and there is little certainty of introducing the needle at the right point. Moreover, if the hair be allowed to remain, tension upon it will usually reveal the direction of the follicular portion, and the needle introduced at the mouth of the follicle and pressed down into the skin as near to the hair root as possible, will be far more apt to reach or approach the papilla than as though it had been introduced into the follicle after the extraction of the hair. Upon the cheeks and chin, where the skin is thick and the follicles slightly patulous, I have found it convenient to use the soft platinum wire after removal of the hair. Beneath the chin, however, and upon the neck where the skin is comparatively thin, I prefer to use the stiff, yet flexible needle, introducing it before removal of the hair. There is one advantage lost by removing the hair before the introduction of the needle. We have in that case no test of the successful result of the electrolytic action. On the other hand, if the hair be not extracted at the outset, we can judge of the effect produced by the electrolysis. If the hair comes out when pulled very gently, it is probable that the papilla is destroyed, but if upon traction with the epilating forceps it seems to be as firmly rooted as at first, it is a proof of the inefficacy of the operation, and suggests a re-introduction of the needle and repetition of the electrolysis.

As regards the strength of the current to be used, no absolute rule can be laid down. The stronger the current, the more rapid will be the effect and the greater will be the pain. From five to ten cells of the ordinary zinc and carbon battery may be used, the number selected being dependent upon the susceptibility to pain and the courage of the patient. In no case can the hair papilla be destroyed without some pain, and the patient will naturally stand a trifle more when there are only one or two hairs to be destroyed, than when there are several hundred. The current must be strong enough to cause decomposition of tissue, which will be manifested by the escape of fine bubbles or froth, by the side of the needle at the mouth of the follicle. When the patient is not particularly sensitive, a sufficient number of cells may be employed to produce this peculiar frying of the tissue immediately after the commencement of electrolytic action. With a weaker current this escape of bubbles may not be noticed until a few seconds after the completion of the circuit.

The first effect of the operation is to produce a small whitish elevation around the mouth of the follicle; in fact, an urticarial wheal. After a protracted sitting, the part operated upon will be acutely congested and somewhat swollen, and the number of hairs operated on can usually be determined by gently passing the finger over the skin and counting the number of small lumps resulting from perifollicular exudation. On the following day the diffused congestion will have disappeared and left a number of red papules or small pustules at the mouths of the follicles. These quickly disappear, and we have only to wait patiently for a few weeks to determine how many hairs have escaped destruction. Without an unusual amount of skill and practice on the part of the operator a certain number are almost sure to grow again, and of course the operation must be repeated until all are destroyed. When there are but one or two strong hairs growing upon the cheek from a small hypertrophic nævus, both the hairs and the "wart" from which they spring can be easily destroyed by a single operation, but when a patient has several hundred scattered hairs growing upon her cheeks and chin, successful treatment will require much time and patience. The soft, downy hairs which often grow luxuriantly upon the upper lip and cheeks of certain women, are not amenable to treatment, and fortunately, these are not incompatible with female beauty. But whenever the hairs grow long and strong and dark, they may be permanently removed by electrolysis.

RASHES PRODUCED BY DRUGS IN DAILY USE.

THERE are certain well-known and constantly-used drugs which give rise to cutaneous eruptions, which are very alarming to patients and puzzling to those administering the offending agent; unless they are quite prepared for such a result; hence it is of the greatest importance that all who have to do with the administration of medicine should be able to recognize such rashes, and so allay at once all anxiety.

To classify somewhat we must place these remedies under two categories:—1. Those which produce their effects by internal administration; 2. Those which give rise to irritation by outward application. In the former we place arsenic, iodine, iodide of potassium, bromide of potassium, belladonna, hyoscyamus, copaiba, chloral. Under the second heading we group iodide of starch, arnica, sulphur, chrysophanic acid, and croton oil. Tar comes under both headings, for if given internally, it not only causes great irritation of skin, but other and apparently more alarming general symptoms, and used too frequently externally it gives rise to acne: Neumann found that in tar manufactories the workmen suffered from this form of disease owing to the local action of the tar vapor.

It must not be for a moment supposed that these drugs will always produce such effects whenever and to whomsoever given, for as a matter of fact there are all grades of liability—some, no matter how large the dose, never suffer at all; others again can take a moderate dose without any bad result; others again are susceptible to the smallest dose, and so much is this the case that such persons cannot take the offending drug in any shape at all.

We will commence with chloral. This drug has been and still is so largely used that it is well to be aware of the fact that it may produce redness of conjunctivæ and also of face (erythema). Dr. Oscar Liebreich seems to refer such a result to impurities. In the case he mentions he demonstrated that the symptoms mentioned were due to admixture of chlorine.

Copaiba comes next and produces a most puzzling rash, sometimes covering the whole body, and giving rise to a suspicion of measles, but there is no rise in temperature, no running at eyes and nose, no crescentic outline of rash, general health not affected. There is usually much itching, and the eruption resembles that of nettle-rash, but without any wheals, and then of course there is the fact that the patient has been taking the drug, and most probably a still further history of gonorrhœa. Dr. Tilbury Fox mentions that he has seen one part of the rash like measles and another like scarlatina, but this condition was an early one.

Henbane, in the form of leaves, taken by mistake has given rise to a red rash like scarlatina, but this is a single case, and the same has not been recorded of any of the officinal preparations, so that in any doubtful case it would be enough to discover that henbane had been administered.

Belladonna produces a rash like that of scarlet fever, with even fever and dry throat, and thus, on the principle *similia similibus curantur*, has secured an important place in the homœopathic pharmacopœia as a certain cure for scarlet fever. There will, in such cases, be dilated pupils, absence of severe or well-marked mischief about the throat, and generally no history of exposure to infection, and mostly occurring in adults under treatment for some other disease.

Arsenic, like tar, really belongs to both categories, for when handled, as in artificial flower-making, it causes excoriations of the hands, and when used as a dye in socks, gloves, or any article worn next the skin, it is apt to cause eczema. In these cases the occupation of the affected one, or the fact of wearing any article with brilliant green tint, would prevent mistakes. Given internally it may cause redness of skin or even eczema, although this last is rare. It has been said also to induce an attack of shingles, but this seems somewhat doubtful.

Iodine and its effects on the skin may best be studied in the form in which it is most largely administered, as a compound with potassium. The iodide of potash gives rise to acne when given in a large dose, or even a very small dose with some people. The peculiarity about the rash is that it comes often, comes out in isolated pimples, especially about the face, neck, shoulders, and back, and as the first batch fades away so there appears a fresh pimple here and there, and this may go on for weeks or months, so long as the patient is taking the drug, without giving rise to any serious discomfort. As a rule there is not much itching, and the chief annoyance is in the disfiguring effect produced. It is well to remember that this rash may appear without any of the symptoms of iodism, such as pain in head, running from eyes and nose, and suffusion of conjunctivæ.

This drug may produce a vesicular or bulbous eruption. Such cases have been recorded by Drs. Tilbury Fox, Broadbent, and others. It may give rise also to purpura, and even to a fatal result, as in the following case recorded by Dr. Stephen Mackenzie in the "Transactions of the Royal Medical and Chirurgical Society:"

"An infant aged five months, with well-marked congenital syphilis, had prescribed for it a mixture containing iodide of potassium in 2½ grain doses. In three-quarters of an hour after taking the first and only dose the child's face was noticed to 'turn black,' and, as this increased, the child was brought to the hospital three hours after taking the medicine. When first seen the whole of the face was swollen, of a purplish-black tint, eyelids closed from extravasated blood, lips and chin tensely swollen, and of an almost black color. The cheeks were discolored by aggregated patches of purpura. There were a few spots on each arm, but none elsewhere. A few abortive pustules were scattered over the body. While the patient was watched the purpuric patches perceptibly increased in size, until in the course of an hour or so the scalp and face were fairly covered. Next day the whole face was swollen, and of a port-wine color, and there were purpuric spots on both arms and legs. The extravasated blood underwent some changes of color, and parts of the skin of the face became necrosed in the course of this and following day. The child died in 68 hours, and analysis proved the medicine free from iodine, and made it certain that the child had not taken more than 2½ grains."

Bromide of potash also produces a rash similar to that of the iodine, but when the two salts are combined they give rise to a more serious and disfiguring result. At a meeting of the Clinical Society on February 8, 1878, Dr. Crocker brought forward a somewhat rare form of bromide eruption in this country, but which seems more common in France, where the drug is extensively used, and in large doses. Dr. Crocker thus describes the case: The patient was a man aged 49, suffering from paralysis, and had been taking 10 grains of bromide with 5 of iodide, three times daily, for nearly a month, when an acneiform eruption began to appear on the face. The rash commenced on January 23, and he was seen by Dr. Crocker on February 6. On each cheek there was a raised patch the size of a crown piece, of a dull livid red color, boggy, and covered by a scab, while at its margins were several yellowish points, exuding pus, epithelium, and sebaceous matter. There were smaller patches on the alæ nasi. Since that date the eruption diminished. No trace of iodine or bromine could be found in the urine. Small doses seemed capable of producing it, and the opinion that it was due to a special idiosyncrasy seemed pretty general, although, judging by the experience in France, large doses had something to do with it. The bromide rash may appear in a suckling infant whose mother is taking the remedy. This case has been detailed because it seems to bring vividly before the mind the disadvantages attendant on the use of these most important and useful drugs, and because such a case is more apt to engage the attention to details.

We come now to irritation of the skin by local remedies, the rash generally being due to their topical irritant effects; but when these applications are made to a large raw surface, absorption may occur, and the same results be brought about as by internal administration. Iodide of starch was for a time very fashionable in the treatment of sores due to syphilis, and here the iodine may be absorbed, and give rise to a sharp attack of urticaria, as described by Dr. Tilbury Fox. Arnica may also give rise to swelling and redness of the skin, and it may be well to state here, what all who have had to do with the treatment of wounds must have noticed, that even the mildest applications will sometimes induce great local irritation—thus, water-dressing applied for any length of time will induce a peculiar rash, causing the most intense itching, and leaving behind a raw surface. Poultices will sometimes bring about the same result; and we have seen this same pustular rash as the outcome of the antiseptic method of treating wounds. Sometimes the rash appears in a day or two.

Sulphur plays an important part in these rashes, because it is still so largely used in the treatment of scabies, or any suspicious eruption about the hands and wrists. It gives rise to a dry state of skin, but may set up eczema, and then the scratching may make matters far worse. It is not uncommon for the irritation produced by the sulphur ointment to be mistaken for the original disease, and thus cause a more vigorous use of it, with the result of much aggravating the condition it is intended to cure.

Croton oil is familiar to all as a favorite and powerful counter-irritant. It gives rise to a series of small pustules with some redness. It should on this account be used with care in all cases of delicate or easily-irritated skins.

Chrysophanic acid ointment has been much vaunted as a remedy for psoriasis, but it is so very irritating that it requires great caution in its use. The first case in which we saw its effects was in hospital practice. A woman with psoriasis about the arm and shoulder was told to apply the ointment, but returned much disgusted in a day or two to say that her linen was spoiled, and it was found stained of a deep, dark purple color, and, in addition, there was severe erythema extending from the seat of disease up the arm. The ointment was discontinued, and the irritation soon subsided. In another case the ointment was applied to a patch over the knee; it caused erythema all round the part affected, and gave rise to conjunctivitis, which lasted two or three days, but in each case the local disease was removed. It is also said to turn the hair a peculiar purplish brown tint and to stain the skin, but Dr. Balmann Squire states that this may be removed by benzol.

It must not be forgotten that most agents used as counter-irritants will, if persisted in for any length of time, and more especially if combined with excessive friction by over-anxious patients, especially if advanced in life, give rise to more or less eczema.

The diagnosis of these rashes depends on the acquaintance of the observer with the fact of their existence as due to remedies, and in such cases a careful inquiry into any possible use of such drugs will clear up the mystery.

As to treatment, in the majority of cases it is simple enough. At once cease the use of the offending agent, and the effect will disappear, but if this does not occur satisfactorily, emollient and soothing applications should be used, the simpler the better, such as sweet oil, simple cerate, etc. Baths are often of great use, especially in causing the entire removal of any local irritating agent; and may be used warm with bran or alkalies, but carefully eschewing the use of soap.

With regard, however, to the two most important drugs, iodide and bromide of potassium, it is often of the utmost importance to continue their administration, and often by quietly persisting with the medicine the rash ceases to appear, or only comes out in isolated acne spots, which the patient does not mind. In other cases the distress is so great, and the disfigurement so obnoxious, that a continuance of the remedy is impossible, unless one can find some combination which will prevent this. Dr. Grimes states that in arsenic we possess the means of preventing the above-mentioned drawbacks—it may be given in the form of Fowler's solution, in doses of three to five minims, and in troublesome cases is well worth a trial.—*Chemist and Druggist.*

CARBOLIC ACID IN SMALL-POX.

By A. R. PLATT, Medical Officer, Imperial Maritime Customs, Ching-kiang, China.

OF the value of the acid as an internal agent in the treatment of small-pox I am now unable to speak, but I have good reason to regard it as possessing power to abort pustulation if brought in direct contact with the eruption. For the past six years it has been my sole remedy in the treatment of small-pox, with the exception mayhap, of a night draught or a laxative—and during that period I have used it constantly in a somewhat extensive foreign and native practice. I cannot better explain my method of treatment than by an example from my case book:

E. S., aged 34, merchant, has not been vaccinated since infancy; was taken ill at Shanghai, January 10th, twelve days after his visit to a man-of-war in this port of Chingkiang on which small-pox had appeared some days before. Returned to his home on the third day after the disease had declared itself, and I saw him at midnight. Patient delirious; high fever; pulse 130; temperature 102°. He was at once placed in a large apartment with an open fire, the windows were opened, and venetians closed to exclude light. (The windows were not again closed during his illness, although snow fell and the weather was unusually severe.)

January 14th.—The eruption has appeared, the face is much swollen, the eyes cannot be opened, there is a copious flow of saliva, and the patient is unconscious. Pulse 110: temperature 100°. Ordered to have face, neck, and arms frequently and freely anointed with a solution consisting of acid carbolic, ʒ jss.; glycerine water, ℥ss, ℥ i., and to have the entire body sponged twice daily with a like solution.

January 16th.—Patient much better. Pustulation fully accomplished, and there is no delirium, and little fever. The pulse never again rose beyond 85, or the temperature above 99°. On the eighteenth day he visited me at my office, and while his face exhibited proof of how extensive had been the eruption, I was able to assure him there would be little sign left of his trouble, and so it proved, for I saw him after an interval of a year, and the pits on his face were limited to five.

I have not spoken of his secondary fever, because there was none, and it is a stage in small-pox I have long ceased to anticipate, regarding it as "dependent on absorption into the circulation of pus in a state of decomposition, or some product arising therefrom," which may be destroyed as formed, or even its formation prevented by an antagonistic agent, like carbolic acid. The application of a strong solution at first gives great pain, but very shortly is readily submitted to, even asked for, as it allays irritation and the desire to scratch. Those pustules which are disposed to coalesce remain discrete, while those which are scattered fail to reach the size arrived at on such parts of the body, where, experimentally, the lotion is not applied. This at least has been my experience.—*Medical Record.*

GANGRENE.—BENEFIT OF HOT-WATER BATH.

DR. FORREST presented to the N. Y. Pathological Society an interesting specimen of gangrene of the leg resulting from the use of the plaster of Paris splint in a case of compound fracture of the femur. The case was specially interesting from the benefit which followed the use of the hot-water bath.

A child, aged four, on December 3d, fell from the third story of a tenement-house, a distance of thirty feet. On examination, a compound fracture of the left femur existed. The child did well for five days, when the medical attendant placed the limb in a plaster of Paris dressing. Much pain was complained of, and after two weeks gangrene of the foot developed. There was no union of the fractured femur. Dr. Forrest saw it on December 15th, and at that time there were no evidences of a line of demarkation. The limb was placed in a tin trough, and water of 112° Fahr. poured over it continually; virtually it was in a bath of water of that temperature. The immediate effect of the hot water was to relieve the pain. On the second day a line of demarkation appeared between the middle and upper third of the leg. The hot water was used for ten days. In three weeks the child was able to sit up. The fracture of the thigh was united. A circular amputation was made at the upper third of the leg. The important feature of the case was the benefit which resulted in a seemingly hopeless case of gangrene from the use of hot water. When it was applied, the chances of the child living through an operation were exceedingly small, and after its use an immediate change for the better ensued.—*N. Y. Med. Jour.*

A CURIOUS STONE HEAD.

THE Dayton, Ohio, *Journal* describes a curious stone head, about the size of a cocoanut, lately found in some earth thrown out in digging a cellar in that city. The sculpturing is roughly done and bears appearance of very ancient date. The material is white sandstone, the surface black with age, the stone weighing in all six to eight pounds. The features have a half Mongolian, half Egyptian cast; the nose is partly broken, and one side of the head has been destroyed, though not so as to affect the face. The lips are open or so cut as to show the lines of the teeth.

During the last few days the stone has been examined by a number of gentlemen interested in American antiquities, and it is regarded as a very curious and anomalous relic. Dr. Jewett, who is familiar with all the works that have been published on Indian and moundbuilders' relics, said that it was entirely different from anything that he had ever seen in the way of Indian sculpture, and that it was not of Indian origin was further evident from the cast of the features and the beard at the chin. It might be, he thought, nothing but the crude work of some stone-cutter, thrown aside in the lot, but the evidence as to its age was against this supposition. The head was evidently attached to some block or pedestal, from which it has been broken off. At the back of the head there is a small portion of this pedestal as smooth as sawn stone, and if it were a piece of sawn stone its recent date would be established at once. The evidence as to its being a genuine relic, however, is so strong as to overturn any supposition that the stone was sawn, and the method among all primitive nations of rubbing the work smooth by grinding would readily account for its appearance. No such stone as the material of the head, Dr. Jewett says, is found south of Berea in Ohio.

Mr. Pretsinger, who has paid considerable attention to American antiquities, thinks the features differ from the purely Egyptian and resemble some specimens of ancient American sculpture that were illustrated in the *Popular Science Monthly* not long ago. He pointed to the fact that while the work is crude it has a completeness in connection with its evident antiquity that precludes the idea that it is of recent date. It represents a certain type of face that the artist must have been acquainted with, and not the chance expression that might have occupied the mind of an apprentice. Both Mr. Pretsinger and Dr. Jewett agree that in Indian sculpture, or in the relics found of the moundbuilders, there is no sculpture of adults among which this specimen can be classed. If it is genuine its origin extends back untold ages previous to the existence of the Indians and their predecessors, the moundbuilders. A theory suggested by Mr. Pretsinger is that it may belong to the period when the Miami river formed an outlet of the great lakes to the Gulf of Mexico. Geologists state that an examination of the river bottom of the Miami shows that it must have been at one period a stream of greater volume even than the Mississippi, and to this period Mr. Pretsinger suggests that the relic may belong.

VOLCANOES OF THE PACIFIC COAST.

THE Journal of the American Geographical Society for 1879 contains an interesting article on this subject, by S. F. Emmons, of the Survey of the Fortieth Parallel.

Mr. Emmons considers that in tertiary times the great interior basins, between the Rocky Mountains and Sierra Nevada, must frequently have been the scene of terrific volcanic action. In the upper basin of the Columbia and Snake rivers, tens of thousands of square miles were covered by continuous sheets of volcanic rocks, often many

feet in thickness. As the massive eruptions of volcanic material gradually ceased, and the gaping fissures in the earth's surface healed and were covered over, we may imagine along the western coast of that time a line of volcanic vents, like beacon-fires, lighting up the rocky headlands, from which issued almost continuous clouds of steam and sulphuric gases, accompanied by frequent showers of rocks and ashes and overflows of hot lava, which gradually built up, around the orifices, immense mountain-masses. At what time these irruptions ceased we have no means of determining. In the cold, white glacier-scored peaks, the casual observer would scarcely suspect these ancient fiery mountains; yet, even now, there slumbers within their mass a spark of the ancient fire, which may some day break forth into conflagration. Through the crest of the Cascade range extends the American segment of that "Ring of Fire" which surrounds the Pacific Ocean. The more prominent of the volcanic cones represented here are Lassen's Peak and Mt. Shasta, in Northern California; Mt. Pitt, the Three Sisters, Mt. Jefferson and Mt. Hood, in Oregon; and St. Helens, Adams, Rainier, and Baker, in Washington Territory. Along the Sierra Nevada proper, which was left above the sea long before tertiary times, volcanic activity has been confined to a few small volcanic vents along its eastern base, near Mono lake, and to flows of basaltic lava on its western slopes, which have, in many instances, covered the gold-bearing gravels of the late tertiary times. In the midst of the lake is a small island, which contains a crater and abounds in hot springs, while to the south of it extends a line of volcanic craters, forming a low ridge, relatively unimportant by the side of the towering Sierras, but extremely remarkable as being the only place where the black glass, known as obsidian, so much prized by the Indians for making their arrow-heads, is known to occur in any considerable quantity. Small fragments may be found in almost any part of the Rocky Mountain region, often hundreds of miles distant. The craters are generally surrounded by a "cinder-cone," or a circular, rampart-like ridge of loose scoriæ and volcanic ash, within which are piled up irregular masses of black and gray glass and white frothy pumice, the latter so light as to float on water, and often drawn out in silky threads like spun glass.

To the technical geologist, Lassen's Peak is, perhaps, the most interesting of all. It was in its study that Von Richthofen gathered the most important facts which led to his classification of the relative ages of volcanic rocks. Here are found traces of long continued volcanic activity, remnants of ancient craters formed and destroyed ages ago. To the original andesitic eruptions have succeeded those of trachyte and rhyolite; the latter in the remarkable granitic form known as nevadite, the masses of which, in cooling, have shrunk and split up in the most remarkable manner, resulting in a confused region of riven rock-masses, to which the appropriate name of Chaos has been given. The final flows have been of basalt, which rock has covered such immense extents of country to the north and east. Indications of the internal heat still remaining, at no great depth beneath the surface, are found in its solfataras and hot springs, from which there is a constant escape of sulphurous gases and steam; these are concentrated in the basin of an old crater, christened in the characteristic Californian vernacular, Bummer's Hell. Here, also, are found the so-called "mud volcanoes;" little conical mounds only a few feet in height, with a central orifice, which from time to time throw out masses of soft, wet mud; within them a constant rumbling, like subdued thunder, may be heard at all times; and, by plugging up the orifice, an artificial eruption may, after a short interval, be produced, and the plug will be thrown out with great force.

Shasta is another old volcano, and northeast of it are immense tracts of country covered by flows of basaltic rock. Broad stretches of table-topped ridges are cut through in every direction by an intricate network of narrow gorges and ravines, abounding in natural fortresses and caves, and traversed by streams, which frequently disappear for distances of many miles beneath the horizontal beds of basalt, to reappear in a most unexpected manner. It was in such "lava-beds" that, during the late Modoc war, a mere handful of Indians were able, by their intimate knowledge of the intricacies of the region, to hold at bay the whole military force that could be brought against them.

East of Mt. Pitt are numerous lakes, which are probably fed largely from springs issuing from the volcanic rocks. Most interesting among these is Crater Lake, which fills an ancient crater about eight miles in diameter. Its walls rise from 500 to 1,500 feet above the level of the lake, and it is difficult to reach the shores without the aid of ropes. The showers of ashes which once issued from this crater can easily be traced by the peculiar character of the soil for a distance of about 28 miles east and 10 west of the lake.

In the region of the Columbia river, which presents some of the grandest and most picturesque scenery of the United States, the volcanic phenomena both of massive eruptions and crater cones, attain an enormous development and can be seen under the most favorable circumstances. This river, which drains an area of nearly 200,000 square miles, has cut its channel, in a canon-like gorge, transversely through the Cascade mountains almost down to the level of the sea. By means of the section thus exposed, we are enabled to study the structure of this mountain range to its very core.

At the Cascades, nearly in the middle of the range which forms the limit of navigation from the ocean, and to which point the work of the Coast Survey has been carried so as to furnish trustworthy measurements, the basaltic cliffs rise 3,700 feet, nearly perpendicularly, above the river. A thickness then of over 3,000 feet of lava has been accumulated from massive eruptions to form the range at this point. At the base of the cliffs is found a conglomerate or pudding-stone—a rock made of round pebbles and gravel, which time and pressure have compacted and hardened, and which here indicates a former shore-line that has been covered by the basalt. Within the conglomerate are found trunks of trees, some changed to stone, some merely carbonized, with leaf remains, which enable us to determine the geological age of the period immediately preceding the building up of the range at this point. This was the miocene tertiary, a time when a tropical climate prevailed over our whole continent, even far up into the Arctic regions.

This bed of conglomerate also gives a clew to the history of a more recent period, to a change in the course of the river and the formation of the cascades themselves. The Cascades are rather rapids than falls, where the river descends rapidly for a mile or two, in one place foaming and boiling over masses of broken rock. A railroad, six miles in length, conveys passengers from the steamer which comes from Portland to that which runs to the Dalles from the head of the Cascades. Just beyond this railroad may still be distinguished in the forests, which cover the bottom of the canon—here considerably wider than the bed of the river—the traces of an ancient stream-bed, somewhat higher than the present one, but which at no very distant period was evidently occupied by the river, being more in its direct course than the bed it now occupies at the Cascades. Indians tell us that there was once a natural bridge at the Cascades, by which their ancestors used to cross the river, and this is rendered probable by the existence of flat, table-like masses of basalt on either side, which might have formed the piers to such a bridge. Again, along the shores of the river, above the Cascades, are great numbers of dead tree-trunks, standing in the water and partially submerged even at its lowest stages. Pine trees would not have grown to such a size in the water, or even if they had, what should have killed them all so uniformly? The explanation seems simple enough when all these facts are combined. At the time when, in the course of cutting this cañon through the mountains, the river had reached nearly its present level, but was still running in the old stream-bed, its waters found a new outlet by perforating this permeable stratum of conglomerate. The opening thus made grew rapidly larger, owing to the easy disintegration of the conglomerate, until it was large enough to take the whole stream; and this bed being at a depth much lower than the present, the old stream-bed was abandoned, and along the upper side of the river the trees grew down to its very edge, while the river, for a short distance, had the character of the lost rivers, being concealed beneath the basalt bridge; but in course of time the supports of the bridge were undermined and the whole mass of overhanging basalt fell into the stream, damming it up so as to produce the present Cascades, and causing a rise or "backing up" of the water in the upper part of the stream, so that the trees along the edge, having the soil washed away from their roots by the rising water, gradually died and decayed, leaving only the stumps we now see lining the borders of the river.

In addition to Mr. Emmons' paper, the volume contains a description of the diamond fields of South Africa, by Wm. J. Morton, M.D.; a discussion of the King of Belgium's plan for the civilization of Central Africa, by means of lines of stations; an exceedingly valuable paper by the Rev. Dr. Selah Merrill upon his late scientific researches into the archæology of Palestine; long papers upon a journey up the Magdalena river, and across the Andes, describing the discovery of the prehistoric statue of "Chac-Mool," in Yucatan. There are several minor contributions, and the whole volume richly repays perusal.

THE FORMATION OF DELTAS.

THE absence of deltas at the mouths of the rivers Weser and Elbe has been explained by saying that from the long-continued erosion and deepening of their valleys, these rivers have not sufficient fall, and consequent force, to transport sand and mud particles in any great quantity to their mouths. To test this, Herr Credner has lately inquired into the fall of a number of delta forming rivers from where they leave the mountainous part of their course to the mouth. In the Ganges this is 2·4 ft. per geographical mile, in the Nile 2·6, in the Danube 1·4, in the Volga 1·5, in the Rhone 7·8, and in the Rhine 4·1. Now, the fall of the Elbe (which has no delta) is 2·9 ft. per geographical mile, and so greater than that of the Ganges, the Danube, the Volga, and the Nile, which shows the necessity of some other explanation. Herr Credner points out that when rivers by erosive action carry along sand and detritus, they deposit them at their mouths; but the deposits could not of themselves, under the most favorable conditions, reach above the surface of the river. But only those deposits are known as deltas which rise above the water surface and add to the dry land by their growth. Now, as they are formed under water, but afterward project above it, they must owe their exposure to a change of level, an upheaval. Hence this fundamental cause of delta formations is gradual rise of the flat ground at a river's mouth. Of the 66 known deltas, 16 belong to coasts, regarding which no observations of the kind referred to are forthcoming, and of the remaining 50 there are, in point of fact, 47 on coasts that are known to be in a condition of secular elevation. The deltas of two rivers (the Rhine and the Nile) belong to coasts which in comparative recent times were in course of elevation; but now a sinking is manifest, in consequence of which the deltas are slowly disappearing. Only one delta seems to be an exception, viz., that of the Po, which, notwithstanding the depression which is occurring at that part of the coast, is rapidly increasing. Herr Credner defers the discussion of this case for another paper. With this exception, then, the rule is general. In lakes, of course, great evaporation, causing a general depression of the water level, has the same effect as regards delta formation as the elevation of the land on the sea coast.

THE MEAN DEPTH OF THE SEA.

IN view of the vague and variable statements as to the mean depth of the sea, given in geographical text books, Dr. Krümmel has examined the materials furnished by recent soundings to obtain, if possible, a more correct estimate, which he sends to the Göttingen Academy. Soundings were wanting for the Antarctic and a part of the North Polar Sea, *i. e.*, about 475,000 square miles, or 7 per cent. of the entire sea surface, so that he gives his estimate only as a closer approximation. He estimates, then, the mean depth of the sea as 1,877 fathoms, or 3,432 meters, or 0·4624 geographical mile. It was natural to compare the mean height of dry land above the sea level. Humboldt's estimate of 308 meters is regarded as quite out of date. Leipoldt has since estimated the mean height of Europe as 300 meters. Accepting this number for Europe, 500 for Asia and Africa, 330 for America, and 250 for Australia, Dr. Krümmel obtains the mean of 420 meters, or 0·0566 mile. The surface ratio of land to water being considered 1 : 2·75, the volume of all dry land above the sea level is inferred to be 140,086 cubic miles, and the volume of the sea 3,138,000 cubic miles. Thus the ratio of the volumes of land and water is 1 : 22·4. That is, the continents, so far as they are above the sea level, might be contained 22·4 times over in the sea basin. Reckoning however, the mass of solid land from the level of the sea bottom, the former would be contained only 2·443 times in the sea space. Dr. Krümmel also compares the masses (taking recent data); he finds that of the sea 3,229,700 cubic miles, and that of the solid land 3,211,310 (a small difference). If the specific gravity of the land were raised merely from 2·5 to 2·51432, we should thus have perfect equilibrium. Such equilibrium is probably the fact.

ALLIGATORS IN THE YANGTSZE-KIANG.

AT the December meeting of the Shanghai branch of the Royal Asiatic Society, a paper was read by M. A. A. Fauvel, on the alligators of China, on which occasion the author exhibited a live specimen, obtained last October from Chinkiang, on the Yangtsze-kiang, as well as a cranium and skeleton, and a stuffed crocodile for comparison. Among modern writers, the late Mr. Swinhoe seems to have been the first to allude to its existence, and in 1869 a specimen was exhibited in the Chinese city of Shanghai. Père Heude more recently nearly became the possessor of a specimen which he only lost through his servant haggling over the price. At various times reports have reached Shanghai of crocodile-like animals being seen in the Yangtsze-kiang, but Mr. L. E. Palm, of the Chinese customs service, was the first to obtain a genuine specimen, which was presented to the Society last year. A careful examination soon showed, according to M. Fauvel, "that it was no crocodile, but a genuine alligator, a most interesting fact, as hitherto no alligator has been met with in the Old World, the genus being supposed to be confined to the rivers of America." M. Fauvel then explained from the specimens, and by means of careful drawings, the peculiarities of the genus. The Chinese animal seemed to resemble most the *Alligator lucius* of the Mississippi, but, as it seemed to belong to a distinct species, he proposed for it the specific title of "*sinensis*," until further research should establish or disprove the distinction.

INTELLECT IN BRUTES.

WE have another batch of letters on this subject, the essential points of which we shall endeavor to give in brief space :

Mr. Wm. Hogg tells us of an incident he witnessed when calling on Mr. W. H. Michael, a gentleman well known at the parliamentary bar, who resides at Queen Anne's Gate, St. James' Park. While they were sitting in the study, the French window of which communicates with a garden at the back of the house, and had a crank latch by which it could be opened on either side, a cat presented herself outside the window, pleading for admission. She continued to plead for some time, and finding no help from within she resolved to trust to her own powers. Eying the latch, which was four feet above her, she made a spring, caught hold of the crank with her fore feet, and putting her hind feet against the other half of the window as a fulcrum, she pressed open the window. This she would do several times in succession. Mr. Michael informed Mr. Hogg that the cat had never been taught to do this.

D. R. S. sends the story of a little terrier that left her puppies only once a day to be fed, gulping down hurriedly a great quantity of porridge. Returning quickly to her family she would put up all the porridge in order that she and her puppies might together enjoy a hearty meal. When the terrier was scolded for a fault it rushed away to a little distance, and catching up anything it could get hold of at once—a bit of stick, a straw, a slipper, or anything at hand—it would come coweringly and lay it down at our feet, with an expression of utter submission. If we were not propitiated it would run off for a second time and bring another peace-offering, often in its distress catching things it would not at any other time have dared to touch.

M. W. T. writes: A farmer, in Somersetshire, was going to a neighboring village some three miles distant, and, not wishing to take his dog, he ordered him home. The dog reluctantly obeyed. When the man arrived at a spot about half way on his road, where the short cut he had taken across the fields joined the more circuitous road, he found the dog waiting for him. Evidently the animal had taken the longer route, which he doubtless knew, calculating on meeting his master at that point, and thus gaining his end without hinderance.

Mr. John Harmer, of Wick, Arundel, possessed, a few years ago, a very fine and intelligent tom-cat, which was much addicted to plundering a rabbit-warren about a mile from his home. After a time it was noticed that before he proceeded on one of his expeditions, "Sam" completed his toilet by wallowing in the filth turned out of the tame rabbits' hutches, he taking particular care that his neck and breast should be in as disgusting a condition as possible, by smearing them up and down till both were saturated and the fur all matted together.

Mr. J. J. Cole, of Mayland, Sutton, Surrey, writes: It has been my custom to have—not a letter-box in a door in the usual way, but the plate and flap in the bottom of a window sash near. I had a cat which often saw a servant go to the window on hearing the flap moved by the postman, and which, when shut out, used to jump on to the window sill and rattle the flap, and when the servant was seen through the glass, jump down to be let in at the door. I knew a horse which, during week days, went round and round to the left, grinding in the cellar of a snuff maker in London. On Sundays, his owner turned him out in a field at his place in the country, where the horse went round and round all day long unwinding himself the other way. Why ?

Mr. B. G. Jenkins describes a scene he witnessed between the large insect known as "daddy long-legs" and a small spider. The former got caught by one of his hind-legs by a pendent thread of cobweb about eight inches long, at the other end of which was the small spider. The spider cautiously descended on the thread, doubling it as he came, and secured the insect's legs more firmly. He then ascended about three inches, and drew the insect up about half an inch; but a violent resistance on the part of the latter induced him to give up the attempt. He, however, went up the thread, strengthening it as he went, and coming down again to the same place, evidently attempted once more to raise his prey, but without success, for the insect resisted so stoutly that it appeared to me to stretch the thread. The spider, Mr. Jenkins writes, saw clearly that the insect was too strong for him, that he would never be able to draw him up to the center of his web, and that if he did not take very summary measures he would lose him altogether; so, on the principle that half a loaf is better than no bread, he set to work to secure a portion of it. The hind-leg of the insect, to which he had his web fastened, was composed of four jointed portions. Round three of these he busied himself weaving a web. Mr. Jenkins noticed particularly that he did not go up to the last jointed portion that attached to the body. Having well secured these three, he moved up to the joint, and for a few moments appeared perfectly still. Suddenly the insect darted away, leaving three-quarters of its leg behind. What other explanation is there than that the spider disconnected it at the joint? Quietly ascending the thread, which he carried with him, and of course the leg as

well, he properly placed the latter, settled down at the union of the two uppermost portions, gorged himself with juices from above and below, and then retired for the night.

Dr. G. Frost sends the following good story:

In answer to Mr. Henslow's request for an example of "abstract reasoning" in the lower animals, I beg to subjoin the following: Our servants have been accustomed during the late frost to throw the crumbs remaining from the breakfast table to the birds, and I have several times noticed that our cat used to wait there in ambush in the expectation of obtaining a hearty meal from one or two of the assembled birds. Now, so far, this circumstance in itself is not an "example of abstract reasoning." But to continue: For the last few days this practice of feeding the birds has been left off. The cat, however, with an almost incredible amount of forethought, was observed by myself, together with two other members of the household, to scatter crumbs on the grass, with the obvious intention of enticing the birds. I think Mr. Henslow might now be convinced that animals also possess in an inferior degree that boasted reasoning power which is generally supposed to belong to man alone. —*Nature.*

ABSORPTION OF WATER BY THE LEAVES OF PLANTS.

ALTHOUGH gardeners universally maintain that growing plants have the power of absorbing water through their leaves, both in the liquid and the gaseous form, in addition to the power of suction through the root, yet the contrary theory has been in favor during recent years among vegetable physiologists.

The first recorded experiment of any value on the subject was about the year 1731, by Hales, as described in his "Vegetable Statics;" the conclusion to which he came being that "it is very probable that rain and dew are imbibed by vegetables, especially in dry seasons." This result was confirmed by Bornet in 1753. A century later, however, in 1857, Duchartre, experimenting on the absorptive power of plants, came, after considerable wavering, to the conclusion that rain and dew are not absorbed by the leaves of plants. This opinion has been, with but little exception, held by all physiologists during the last twenty years, notably by De Candolle and Sachs; the explanation offered of the fact that withered plants revive when placed in moist air, or when the leaves are moistened, being that transpiration is thus stopped, or is more than counterbalanced by the root absorption. In his "Text Book of Botany" (English edition, p. 613), Sachs says: "When land plants wither on a hot day and revive again in the evening, this is the result of diminished transpiration with the decrease of temperature and increase of the moisture in the air in the evening, the activity of the roots continuing; not of any absorption of aqueous vapor or dew through the leaves. Rain again revives withered plants, not by penetrating the leaves, but by moistening them and thus hindering further transpiration, and conveying water to the roots, which they then conduct to the leaves." McNab has, however, proved that leaves do transpire, even in a moist atmosphere, provided they are exposed to the action of light. The result of recent experiments conducted by Boussingault in France, and by the Rev. George Henslow in England, seems to force us to return to the earlier theory held before the time of Duchartre's experiments.

Boussingault's experiments relate not only to the absorption of water by leaves, but also to transpiration under various atmospheric conditions. The first experiments were as to the amount of transpiration from the Jerusalem artichoke in sunshine, in shade, and by night. This he found to be hourly, for every square meter of foliage, 65 grammes in sunshine, 8 grammes in the shade, and 3 grammes during the night. In the vine the corresponding numbers were 35 grammes in sunshine, 11 grammes in shade, 0·5 gramme by night. He reckoned that an acre of beet could give off, in the course of twenty-four hours, the enormous amount of between 8,000 and 9,000 kilogrammes of water; and a chestnut tree thirty-five years old 60 liters of water in the same time. The next question investigated was whether the absorption of water by plants, and the ascent of the sap, are due to the force resulting from transpiration on the surface of the leaves, or whether the roots exercise also a certain amount of force to this end. In the case of mints, a plant with roots showed an hourly evaporation per square meter of 83 grammes in the sunshine, and 36 grammes in the shade; without roots the evaporation was 16 grammes in sunshine, 15 grammes in shade. The effects of pressure on the absorption were next examined. A chestnut branch dipped in water was found to transpire hourly, 16 grammes per square meter; when inserted into a tube of water, and subjected to the pressure of a column of water, 2½ meters high, the evaporation amounted to 55 grammes per square meter per hour, and the branch, at the end of five hours, weighed more than at the commencement. As to the effect of the epidermis in restraining evaporation, he found that an apple deprived of its skin loses fifty-five times as much water in the same time as one with its skin entire; while similar experiments in the case of a cactus leaf showed a difference in the proportion of fifteen to one. Losses by rapid evaporation lessen appreciably the physiological energy of leaves. Thus an oleander leaf containing 60 per cent. of water, when introduced into an atmosphere containing carbonic acid gas, decomposed 16 c.c. of the gas; one containing 36 per cent. of water decomposed 11 c.c.; while one containing 29 per cent. of water was without action. As respects the relative power of evaporation possessed by the upper and under surfaces of leaves, he found the average proportion in a dozen different kinds to be as one in the former to 4·3 in the latter case.

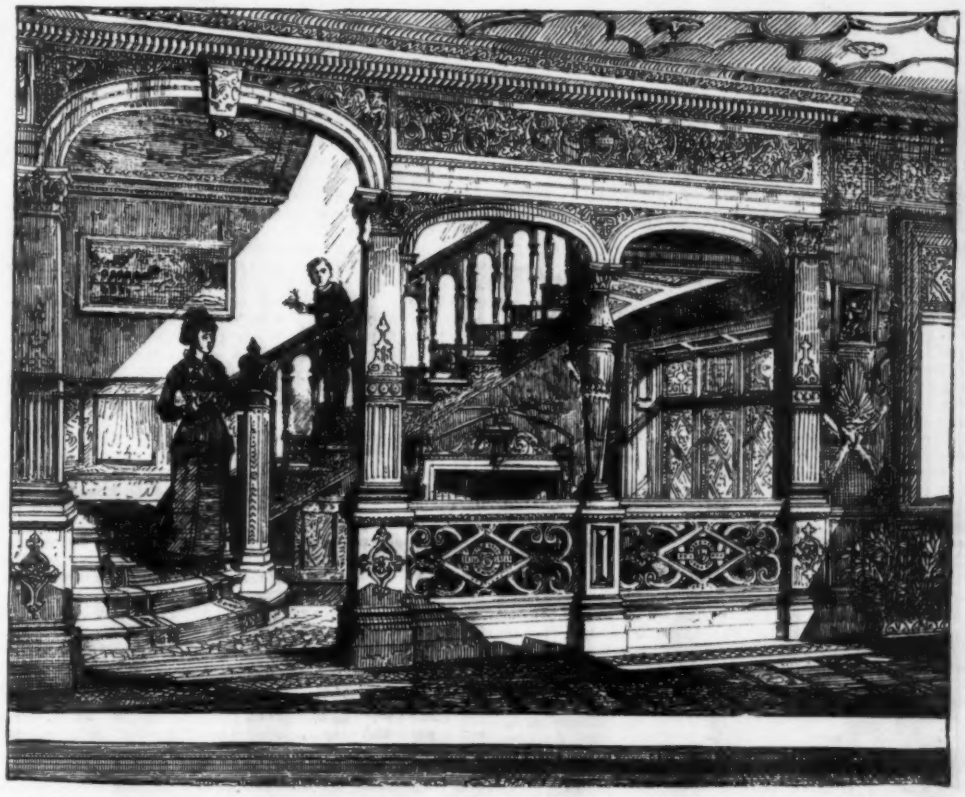
Boussingault then proceeded to investigate the question of the ability of leaves to replace the roots of a plant in serving as the agent of absorption. A forked branch of lilac was so placed that one portion was immersed in water in a reversed position, while the other was exposed to the atmosphere, the superficies of foliage in both portions being the same. The transpiration from the exposed portion was found to be the same as under normal circumstances, and after the lapse of two weeks the foliage was as fresh as at the commencement, showing that the submerged leaves were fully able to replace the roots in supplying the shoot with moisture. A vine shoot half plunged in water, maintained a normal evaporation in the free foliage, and remained fresh for over a month. An oleander shoot, under similar circumstances, maintained its normal appearance for four months. In the case of the artichoke it was found necessary that the amount of surface of leaves beneath the water should be four times that above it. A number of experiments with regard to the power of leaves to absorb water in the state of vapor from a saturated atmosphere, showed that they could do this only when they had previously lost a portion of their water of constitution, *i. e.*, that which is essential to their normal existence. Thus a wilted branch of periwinkle weighing 4 grammes, after remaining for a day and a half in an atmosphere saturated with aqueous vapor, weighed 4·2 grammes; after twelve hours' immersion in water it weighed 9·4 grammes. His last experiments related to the power of leaves to absorb aqueous solutions. Drops of water containing 0·2 per cent. of calcium sulphate in solution were placed on the leaves of a great variety of plants under conditions favoring absorption, and protected from evaporation by inverted watch-glasses with greased edges. In most instances the drops were entirely absorbed, leaving no trace of the mineral matter. As in the case of pure water, the under surface of the leaf absorbs much more rapidly than the upper surface. Solutions of potassium sulphate and nitrate gave corresponding results; the absorption of solutions of sodium chloride and ammonium nitrate was not so perfect. It is obvious that these results must considerably modify the view at present held by physiological botanists, that the small quantity of ammonium carbon contained in the air, which is believed to be the sole source of the nitrogen in the tissues and secretions of plants, can only be absorbed by the roots, after having been brought down to the soil by rain.

Mr. Henslow's results, as detailed in a paper read at a recent meeting of the Linnæan Society, are altogether in harmony with those of the French professor. The results of a very large number of experiments, extending over several years, may be epitomized as follows: 1. The absorption of water by internodes. The experiment consisted in wrapping up one or more internodes of herbaceous plants in saturated blotting paper, and in noting the effects. As a rule, the leaves on the shoots rapidly perished, showing that transpiration was too great for the supply. The stems, however, kept fresh for different periods up to six weeks. 2. Absorption by leaves to see how far they could balance transpiration by others on the same shoot. The general result is that as long as the leaves remain green and fresh, in or on water, they act as absorbents; but that the leaves in air keep fresh or wither according as the supply equals or falls short of the demand. 3. To test how far leaves on a shoot can nourish lower ones on the same. It appears that it is quite immaterial to plants whether they be supplied with water from the absorbing leaves being above or below those transpiring. Water flows in either direction equally well. 4. Leaves floating on water. This experiment showed that one part of a leaf can nourish another part for various periods, though the edges out of water died first. 5. Absorption of dew. A long series of cut leaves and shoots was gathered at 4 P.M., then exposed to sun and wind for three hours, then carefully weighed and exposed all night to dew. At 7.30 A.M., after having been dried, they were weighed again, and all had gained weight and quite recovered their freshness, proving that slightly wetted detached portions do absorb dew. 6. Imitation dew. Like results followed from using the spray, by which dew was exactly imitated. 7. Plants growing in pots, and of which the earth was not watered, were kept alive by the ends of one or more shoots being placed in water; *e. g.*, *Mimulus moschatus* not only grew vigorously and developed auxiliary buds into shoots, but even blossomed.

By these interesting experiments the physiological botanist is again placed in harmony with the gardener, who syringes his plants not merely for the purpose of washing off dust and insects, but in order to facilitate the actual absorption of water by the surface, and with the field botanist who sprinkles the plants in his vasculum with water to keep them fresh till he reaches home. Mr. Henslow concludes with the following hints as to preparing bouquets of cut flowers: If some of the specimens have buds upon them, let the stalks be long, and allow a few leaves to remain on and be also immersed in the water, and the buds will then often be found to expand successfully. The cut end, to be more absorbent than it otherwise would be, should be again cut off under water. If the blossoms be on a ligneous stem, as of lilac, then the loss of water by evaporation is greater than the woody stalk can supply, so that in this case the addition of leaves in the water will greatly aid, and retain the bunch of flowers fresh for a longer time.

OAK STAIRCASE AND SCREEN.

THE view illustrates a new staircase lately erected at a house in Finchley-road, London, being part of extensive additions. The house having been erected in somewhat of the Elizabethan style, the new portions have been made to assimilate with it; the floors also of the new part are made to range with the formerly existing floors of the house. All the joinery of the doors, windows, etc., is of oak well moulded. The floor is laid with parquetry of a special design, and the ceiling (which is in plaster) is designed to suit a central sun-burner by which the room is well lighted; portions of the window are glazed with stained glass, the designs being illustrative of the seasons. The staircase, which is taken from a drawing exhibited last year at the Royal Academy, is of oak. It is situate adjoining a long and handsome corridor, and divided from it by the screen shown in the view. It is lighted by a lofty stained glass window at the side and over the small window shown under the stairs. The newel of the staircase is carved, and the whole work executed by Messrs. Laurance, builders, of Pitfield Wharf, Waterloo bridge. The works, including dining-room and staircase, have been carried out from the designs and under the superintendence of Mr. Henry L. Legg, architect, of Christ's Hospital, London.—*Building News.*



SUGGESTIONS IN HOUSEHOLD ADORNMENT.—AN OAK STAIRCASE.

INTERESTING ANTIQUARIAN RESEARCHES.

THE London *Times* Geneva correspondent writes that the Lake of Neuchâtel is just now lower than has ever before been known, and continues to yield rich rewards to the researches of antiquarian explorers. Prof. Forel found, a few days since, at the lacustrine station of Corcelet, an earthenware vase dating from the age of bronze. On the bottom of the vase are plainly visible the impressions made by the fingers of the prehistoric potter in the plastic clay. Of these fingers—or, rather of the thumb and forefinger, for the other digits are unfortunately lacking—the professor has taken a plaster of Paris cast and submitted them to a minute examination. He pronounces the maker of the vase to have been a woman. There are two impressions of the thumb and three of the forefinger. The prints left by the nails are perfect—that of the thumb, which must have been regular, well-shaped, and of elegant convexity, measures in length twelve millimeters, in breadth eleven millimeters; the length and breadth of the finger nail, equally well modeled, are eleven and nine millimeters respectively, the transverse convexity representing a curve or a rise (*flèche*) of two millimeters. These nails, considers M. Forel, can only have belonged to a female hand. The vase has been placed in the cabinet of antiquities in the Vaudois Cantonal Museum at Lausanne. Another investigator, who has been cutting trenches in ground left bare by the abatement of the waters of the lake, has arrived, after careful examination of the *débris* and relics which his explorations have brought to light, at some interesting conclusions concerning the way in which certain of these lake-dwellings were destroyed, the time of the year when they disappeared, and the level of the lake at the epoch of their extinction. He believes they were destroyed by fire. This opinion he bases on the fact that, in all his explorations, he finds the same mixture of gravel and sand blackened and interspersed with charcoal and partly burnt seeds and bits of wood. The *débris* has evidently been carried to its present position by the waters of the lake, and varies in thickness according to the inclination of the slope on which it has been deposited. In other places besides those where the trenches have been cut, similar indications are observable—for example, at Bied, where, in sinking for the foundation of a house, a lacustrine cemetery was some time ago discovered; and at Colombier, where a stream running over the dry bed of the lake near the shore has laid bare *débris* identical with that brought to light by the excavations in question. From the quality and quantity of the winter stores, such as nuts, seeds, and berries, found among these remains, the burning of the lake dwellings probably occurred in spring or early summer. In one place a vessel was found filled with acorns, which, not being a favorite food, would naturally, it is presumed, be left to the last, and only used in default of something more palatable.

NEW GRAND CEMETERY OR NECROPOLIS IN MADRID, SPAIN.

OUR engraving illustrates the plans for a new municipal cemetery lately adopted by the corporation of the city of Madrid, Spain, which is soon to be inaugurated in the district of Vicálvero.

More than a year ago the corporation of Madrid issued invitations to all Spanish architects for the presentation of plans, and many of the most celebrated members of the profession gave attention to the subject.

Various plans were presented and were then considered by a jury of thirteen distinguished persons, several of whom were experienced architects, who unanimously accepted the plan here illustrated as the best. The authors are Don Fernando Arbós y Tremanti and Don José Urioste y Velada, members of the Academy. Our engraving is from *La Ilustracion Española y Americana*.

The general basis of the project is that of a Catholic cemetery, arranged in the form of a Latin-Byzantine cross. There are three principal divisions. The approach to the cemetery, where are the administrative establishments and receiving places for the dead; the Catholic cemetery, which has at its entrance the chapel and osario; the cemeteries not Catholic, arranged at the sides, which have a secondary importance.

The different classes of sepultures and pantheons are so distributed as to suit the configuration of the ground, and are divided into banks of five meters height, which afford space for crypts in the pantheons, the entrances to which are upon the lower levels, the upper portion being covered by galleries formed with columns and arches; each arch being intended to be occupied by a monument pertaining to the pantheon, which is located immediately under it.

In the middle of the cross are located the sites destined for the interment of distinguished personages; and at the sides, beyond the vicinity of the Catholic grounds, and with independent entrances, are the congregational cemeteries.

In this project the niche method of burial is entirely suppressed, all interments being made in the earth.

The estimated cost of the whole work is $1,700,000. The plan appears to give general satisfaction in Madrid.

PREMIUM DESIGN FOR THE NEW CEMETERY, OR NECROPOLIS, OF THE CITY OF MADRID, SPAIN.

1. THE CHAPEL.—2. PANTHEONS OF THE FIRST CLASS.—3. PANTHEON FOR DISTINGUISHED PERSONS.—4. THE CATHOLIC CEMETERY.—5. SEPULTURES OF THE THIRD CLASS, WITH CINERARY.—6 and 7. SEPULTURES OF THE FOURTH CLASS.—8. SEPULTURES OF THE JUDICIARY.—9. SEPULTURES FOR CHRISTIANS NOT CATHOLICS.—10. SEPULTURES OF CHARITY.—11. OSARIO.—12. THE DEAD HOUSE.—13. LEGAL BUILDINGS AND STORES.—14. OFFICES.—15. DWELLINGS.—16. APPROACH TO CHAPEL.

HOUSE.—13. LEGAL BUILDINGS AND STORES.—14. OFFICES.—15. DWELLINGS.—16. APPROACH TO CHAPEL.